Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

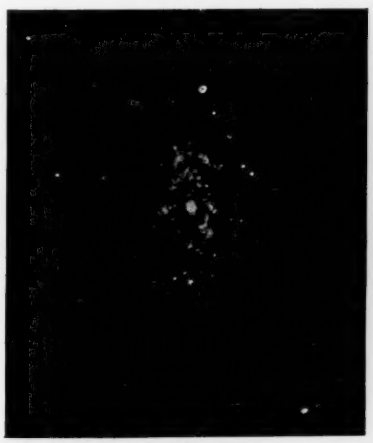
Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

NOVEMBER, 1912.

THE SPIRAL NEBULAE.

By F. W. HENKEL, B.A., F.R.A.S.

PROBABLY no other announcement excited so much interest in the astronomical world about twenty years ago, as that a photograph by Dr. Isaac Roberts of the well-known lenticular nebula in Andromeda (see "KNOWLEDGE," Volume XXXIV, Frontispiece), described by its original discoverer, Simon Marius, as "like a candle shining through horn," and since so often mistaken for a comet, had revealed the fact of its essentially spiral nature. Some there were who thought they saw in this photograph something like a proof of the substantial truth of the Laplacian nebular hypothesis (*e.g.* Darwin's "Mechanical Conditions of a Swarm of Meteorites," 1889). The name nebula, equivalent to the Greek *νεφέλη*, a cloud, was given to cloud-like masses in the heavens, some of which have been resolved into stars, but others are of a totally different character. Next after the nebula in Andromeda, the great nebula in Orion, perhaps the most remarkable of all these objects, was detected by Huygens in 1656. Halley, in 1714, gave an account of six, including the two just mentioned, the nebula in Sagittarius (see Figure 441), the cluster ω Centauri, discovered by himself in 1677, and the cluster in Hercules detected in 1714 (see Figure 440), and finally another in Antinous.



By kind permission of Professor T. J. J. See.

FIGURE 433.
M. 11730 Ursae Majoris.

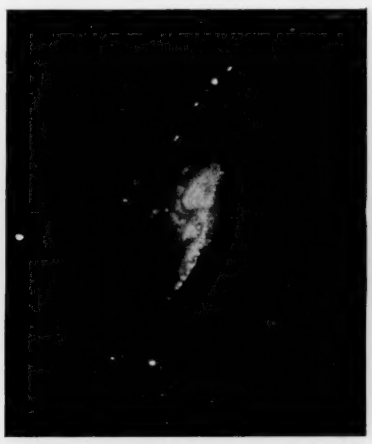


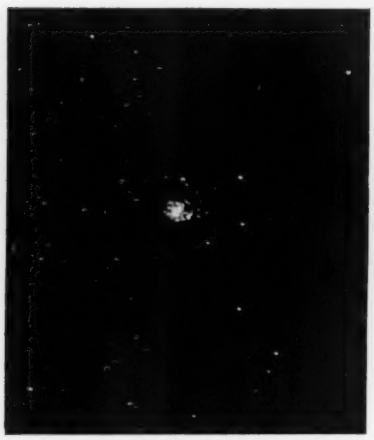
FIGURE 434.
H.V. 43 Ursae Majoris.

FIGURE 435.
M. 100 Comae Berenices.

Spiral Nebulae photographed at Lick Observatory.

XUM

We find here the first germs of a "nebular theory." Halley supposed the light of these objects to be occasioned by a lucid medium diffused through the ether, differing from ordinary matter. After Halley, Lacaille and Messier gave more extended lists of nebulous objects known to exist in the sky. The last named included one hundred and three in his catalogue of 1784, and the letter M. appended to a nebula (or cluster) indicates its inclusion in Messier's list. But the magnificent work of Herschel resulted in the discovery of a vastly greater number: no less than three thousand, mainly discovered by himself, were registered in his catalogues, and he divided them into a number of different groups. His work was continued and extended by his son, Sir John Herschel, into the Southern hemisphere. The two Herschels, father and son, so thoroughly and completely worked at this subject, that though many nebulae have been added by others to their lists, few only of these objects are striking, the numerous small faint nebulae now known being visible only by photographic means or the highest telescopic powers. Sir William Herschel made the following classification of these objects into six different groups: (1) Clusters of stars in which the separate stars are distinguishable. (2) Resolvable nebulae, or such as probably would be resolved into stars by increased optical means. (3) Nebulae which show no signs of resolvability. (4) Planetary nebulae. (5) Stellar nebulae and (6) Nebulous stars. To this we must add the sub-divisions of the irresolvable or probably irresolvable nebulae. (1) Annular nebulae. (2) Elliptic nebulae. (3) Spiral nebulae, the most remarkable and perhaps the most numerous of all. (4) Irregular or amorphous nebulae. Amongst annular nebulae the well-known ring nebula in Lyra, Messier 57 Lyrae (see Figure 439) is perhaps the most interesting. It consists of a nearly circular ring of light with a dark central portion. The latter, however, contains some traces of nebulous matter as seen in the largest instruments, whilst the outer edge of the ring is broken by projections of various sizes and shapes. It has been claimed by some that it is at least partly resolvable into stars, whilst the late Sir W. Huggins considered that it is merely a mass of incandescent gaseous or "ultra-gaseous" matter, with individual stars scattered over it. Of elliptic nebulae the most remarkable and interesting was for a long time thought to be the great nebula in Andromeda, but as we have said, the photographs of Dr. Isaac Roberts have brought out its spiral character. Spiral nebulae were for the first time distinctly known to be such when the great telescope of Lord Rosse was brought to bear upon these objects. Thus, the Nebula 51M. Canum Venaticorum (see "KNOWLEDGE" volume XXXIV, page 417), which Sir John Herschel had considered to be a bright globular cluster surrounded by a bright nebulous ring of varying brilliancy, was shown by Lord Rosse to be of a most remarkable spiral form, exhibiting a series of convolutions. Many other spiral nebulae are now known to exist, and they are to be counted by hundreds, if not by thousands, in the starry heavens. 33M. Piscium and 99M. Virginis are, perhaps, the finest after the nebula in Andromeda and the great whirlpool nebula in the "Hunting Dogs." Probably the most beautiful and satisfactory photographs of spiral nebulae ever taken have been obtained at Lick Observatory, California, U.S.A., by Professor Barnard, the late Dr. Keeler and Mr. Perrine, with the Crossley Refractor, and by the courtesy of Dr. See we give reproductions of six of these objects (see Figures



By kind permission of

FIGURE 436.
M. 99 Comae Berenices.

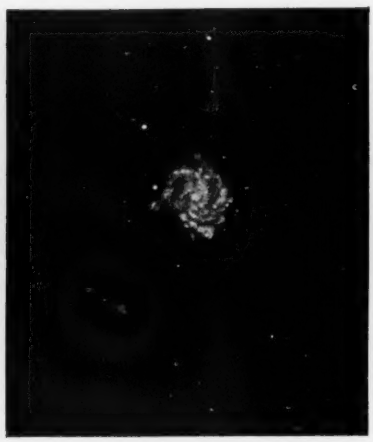
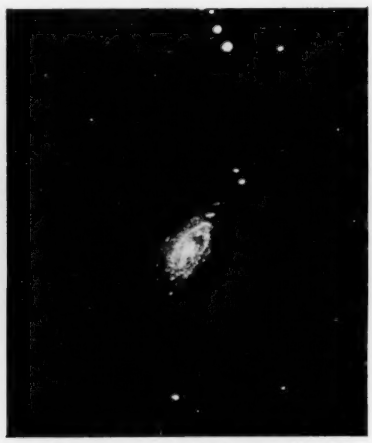


FIGURE 437.
M. 61 Virginis.



Professor T. J. J. See.

FIGURE 438.
M. 88 Comae Berenices.

Spiral Nebulae photographed at Lick Observatory.

433 to 438)—M. 11730 Ursae Majoris, H.V. 43 Ursae Majoris, M. 100 Comae Berenices, M. 99 of the same constellation, M. 61 Virginis, and M. 88 Comae

FIGURE 439.

The Annular Nebula in Lyra.

From a photograph taken at Mount Wilson Observatory, September 17th, 1909, by G. W. Ritchey. Exposure thirty minutes.

Berenices. It is only with large instruments and the highest applications of the photographic art that the beauty and wonder of these objects becomes to some extent manifest. With smaller instrumental means but little information can be gathered. The bulk of the objects given in Messier's catalogue have proved to be remote or highly condensed star clusters; only a few of them appear to be true nebulae. It was on account of this resolution by the application of more powerful optical appliances that the idea was once held that the only difference between these objects was merely a matter of greater or less distance, the nearer clusters being shown to be such by small telescopes, the more remote ones proving intractable. The great telescopes of the Herschels and Lord Rosse succeeded in bringing so many of these objects hitherto unresolved into the resolvable class and it was at one time even thought that the great nebula of Orion itself, most wonderful of them all, showed signs of resolvability. On philosophic rather than strictly scientific grounds the idea had been entertained of the existence of a specific form of substance, "nebulous matter," of extreme tenuity and transparency, with feeble luminosity, differing from the solid, liquid, and gaseous conditions with which we are familiar on our planet. From this matter it was supposed all other matter had arisen by slow condensation, and the irresolvable nebulae were formed of this as yet uncondensed material. These views were supported by Halley, to whom science owes so much both in the way of discovery and suggestion; he supposed "the light of the nebulae to be occasioned by a lucid medium diffused through the ether and shining by its own light." Up till quite recently, however, it has been generally considered that all these bodies were continuous masses in equilibrium or revolving slowly. On the Laplacian nebular hypothesis it was supposed that such a mass by slow contraction gradually left behind rings of matter, which collected into separate globes and formed the planets. The nebula of Andromeda was thought by Sir G. Darwin and others to be an actual example of this process going on before our eyes. But when we consider the enormous size and consequently small density of the nebulae in general, we shall understand the difficulty, nay, the impossibility, of any such condition of affairs. The late Mr. Proctor, editor of "KNOWLEDGE," long ago pointed out other objections. "The nebulae we see have, it seems, a greater analogy with the solar corona than with the fiery condensing mists conceived of by Laplace" ("Old and New Astronomy," § 1445). In another place he says: "Whenever enquiry is made into the Laplacian nebular hypothesis, that will be even more decisively rejected." The views of so careful a writer, who took nothing for granted on the authority of others, are worthy of our most scrupulous consideration. Many of the nebulae have an apparent diameter greatly exceeding that of the Sun or Moon, sometimes extending over the greater part of a constellation; but their luminosity is so small that, as we have said, it is only by the highest optical power that the full extent is realised. On the other hand, stars evidently intimately connected therewith

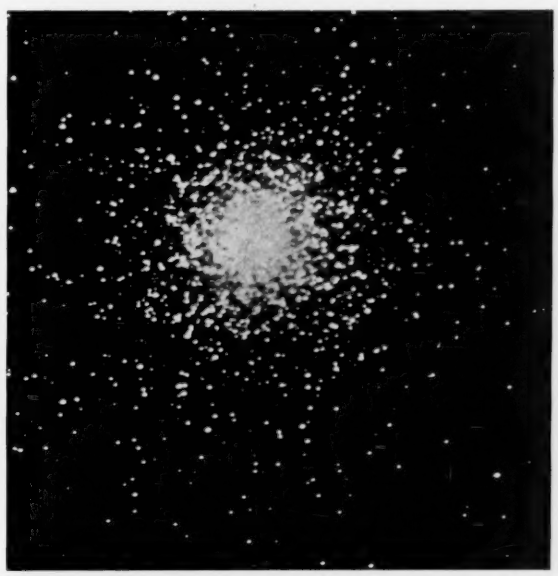


FIGURE 440.

The Cluster M. 13 in Hercules.

From a photograph taken at Lick Observatory on July 13th, 1899, with a Crossley Reflector. Two hours exposure.

XUM

have no excessive proper motions, showing that the masses of their nebulae are very small. "The nebula of Andromeda or the great nebula of Orion must exceed in volume the whole space occupied by our solar system, many thousands, perhaps millions, of times." Such enormous objects cannot remain at a high temperature, for their heat would be quickly radiated into space; and consequently the view that the nebulae in general are highly heated masses of fluid in hydrostatic equilibrium is being slowly, but surely, abandoned. Long ago (in 1861) Babinet, of the "Institut," by simple arithmetic showed that no such nebula as Laplace had supposed could have given rise to the Earth and other planets from rings of abandoned matter left behind during its condensation; for the actual speed of these bodies is much quicker than can be thus accounted for, and "the hypothetical solar nebula could not have rotated with sufficient speed to detach the masses." Thus, such a doctrine of the evolution of the planets by separation of rings of matter from the central condensation by rotational instability must be abandoned. Some have proposed as an alternative that secondary condensation nuclei might be formed by *gravitational* instability within the gaseous "nebula": such a doctrine has been outlined by Mr. J. H. Jeans, of Cambridge, in papers which he has contributed to the *Philosophical Transactions of the Royal Society*.

Mainly by the work of Professor See during the last few years a more rational and consistent cosmogony has been built up. We know that there are vast numbers of *spiral* nebulae scattered all over the sky, and it is supposed that our solar system has been formed from such, and not from a spherical or ellipsoidal mass gradually condensing and contracting. Within such a mass, "a discontinuous cosmical cloud, with vortices formed of streams circulating without exerting hydrostatic pressure between the coils" two or more streams of particles, "cosmical dust," meeting give rise to such a spiral nebula, and it is possible that collision and friction between their parts may give rise to a feeble luminosity, as suggested by Sir Norman Lockyer in his "Meteoritic Hypothesis." Two opposite branches of the spirals thus originate by "the meeting of separate streams or by the settling of one stream towards the centre, so that the branches coil up as they condense" (See). The varied forms of spiral nebulae represent various stages in the development of these bodies, and we may thus form some estimate of their relative antiquity. By actual measurement of a number of photographs, however, Professor See has concluded that their forms are only roughly approximate to true geometric spirals, a mixture of the Logarithmic and Archimedean spirals giving an approach to the most common forms observed. "The older nebulae tend to approach the form of the Spiral of Archimedes, the newer more nearly resemble that of the Logarithmic Spiral, but neither form is exactly observed." Many irregularities occur, as might perhaps be expected, so that he concludes that in reality their true forms are "chance spirals, and necessarily depart from any kind of geometric regularity."

From such a system our own has probably developed. Herbert Spencer was probably one of the earliest to point out that a number of flocculent nebulous masses falling towards a centre would assume the spiral form at a time when few spiral nebulae were known to exist (1858). It is somewhat remarkable that Spencer, whose views on many physical questions were so sharply and justly criticized by Tait, J. F. Moulton and others, should have nevertheless held views on some matters in advance of his critics, specialists in their subjects, just as a century earlier Euler, the great mathematician, held more correct views on many physical questions than contemporary physicists. Within this nebulosity processes tending for division are going on. In many cases we have a division into two more or less nearly equal masses and we have then a double star, of which many examples are to be found in the sky. In others the greater part of the material becomes condensed towards the centre, smaller portions only elsewhere, and we have a predominant Sun and comparatively small planets, as in our own system. By degrees much of the rest of the material will be gradually swept up by the larger bodies, but a portion will remain, the comets, meteorites and matter of the Zodiacal Light (?) Meanwhile this, acting as a resisting medium, will render the orbits of the planets and their satellites more nearly circular, at the same time slightly reducing their distance from the central body. Such an action of resistance was well known to Laplace, who gave a mathematical proof of it in his "Mécanique Celeste" (Book X). It has been supposed that Encke's well-known comet, whose return we have recently witnessed, is gradually drawing nearer to the Sun by such an action. However this may be, the secular action of a resisting medium affords the most satisfactory explanation of the present almost perfect circularity of the planetary orbits.

The views we have here briefly outlined invest spiral nebulae with a paramount interest, for in their development, movements and condensation we may trace the processes which have resulted in the evolution of our own solar system. Just as in the forest we observe vegetation in all stages of growth, from the nuts and seeds, through the young and tender saplings, to the full-grown adults, next the "giants of the forest," and, lastly, the moss-grown oaks and decaying remains of former life, so, too, in the starry heavens we may expect to find worlds, past, present, and to come. A favourite scale gave the nebulae as worlds coming into being, white stars, such as Vega, as youthful orbs, our own Sun as a specimen of a later stage, though still intensely hot and luminous; red stars older still in the course of development, the planets and "dark" suns, as hot only in their interiors, and lastly "dead" worlds, like our own Moon. But such an arrangement, though admired and repeated by popular writers, has little support in facts; it is

FIGURE 441.

The Trifid Nebula in Sagittarius.

From a photograph taken at Lick Observatory July 6th, 1899, with a Crossley Reflector. Exposure three hours.

by no means certain that red stars, though probably cooler, are older than white ones—they *may* be growing hotter; nor is it by any means necessarily the fact that our own Moon once formed part of an intensely-heated mass. However, the tendency of the human mind cannot be withstood, and hypothesis performs a useful function in serving to coördinate the observed phenomena of nature, and in leading us to search for further evidence, which shall serve as its confirmation, or perhaps lead to its rejection in favour of truer views. The immense amorphous nebulae, of no regular form, such as the great nebula of Orion, the nebula round Eta Argus (now often called Eta Carinae), the Omega nebula, the Trifid nebula in Sagittarius (see Figure 441) and the America nebula (so-called from a rough resemblance in its shape to that of North America) (see Figure 442) may perhaps be regarded as "forming portions of the universal chaos in which order has not yet been introduced." The annular nebulae, planetary nebulae and special nebulae represent a later stage. Professor See suggests that such a nebula as the Ring Nebula in Lyra (see Figure 439) has been formed by the union of two streams, indicated by the blurred ends of their overlapping giving rise to the hazy nebulosity at the extremities of the ellipse. The veil or "gauze over the hoop" perhaps due to wastage from the latter by increasing, may gradually cause it to assume the annular form, a more or less uniform disc of light. The researches of Dr. Max Wolf, of Heidelberg, have shown that at least four different gases are present in this nebula, hydrogen, helium and two other as yet unknown substances, one of which may be identical with the "coronium" of the Solar corona. Dr. Fath, of the Mount Wilson Solar Observatory, has recently examined the question as to the true nature of the spectra given by spiral nebulae generally. It had been generally believed that these bodies usually gave a characterless continuous spectrum unmarked by lines either bright or dark, but the great faintness of their light rendered very long exposures necessary to obtain satisfactory photographs of their spectra. Nevertheless such had been obtained, and the result showed that "no spiral nebula investigated has a truly continuous spectrum." The primary or fundamental part appears to be continuous; but it is interrupted by absorption lines, and in some cases we find bright lines or bands. Thus, Professor See infers that this indicates that these bodies, in addition to their gaseous or ultra-gaseous matter, have an abundance of moons and planets scattered throughout their mass; their light may be "due to certain transformations of energy, luminescent effects produced by electric discharges in high vacua and light generated by the impact of the various bodies contained within the nebula." He further supposes that these "moons" arise from the precipitation of ions, and the condensation of cosmical dust on many centres, each such centre being sufficiently distant from any other to be undisturbed by its attraction. After a time in the course of ages many of these "moons" coalesced, and so their number diminished; but the size of the survivors correspondingly increased, impact and collision continually going on. By the impact of numerous smaller bodies, he considers that the characteristic lunar "craters" have gradually arisen, a theory of the origin of lunar surface phenomena quite different from the usually accepted "volcanic" theory, but one which is worthy of consideration and is akin to the views of Humboldt, Gilbert and Proctor on the subject.

If it be indeed the case that our own solar system has developed, not from a nebula of the kind imagined by Laplace, but from a *spiral* nebula which has gradually condensed, and the number of independent members has been reduced by impact and collision to a few whose paths have been rendered nearly circular by the long continued action of the resisting medium, we may learn much of the nature of both spiral nebulae and those of other kinds from the study of the system of which we form a part.

CORRESPONDENCE.

To the Editors of "KNOWLEDGE."

SIRS,—I should feel much obliged if any of your readers would enlighten me on the following point.

The minimum of the mean temperature curve for the year does not, of course, occur exactly at the shortest day, but some weeks after. There can be, unfortunately, no parallel with regard to mean nightly minima, but we have the converse case of the two hours lag of mean daily maxima after midday, when the Sun is hottest, which involves the same principle, *viz.*: that, owing to its accumulative properties with regard to heat, the earth and hence the atmosphere, cannot respond at once to a change of intensity in the Sun's radiation. This can be actually observed on a *clear*, calm day with a suitably-placed thermometer. Again, during the solar eclipse last April, the minimum temperature occurred about twelve minutes after the greatest phase. It was an ideal day in London and clear except at first. Only shade temperatures, of course, are referred to. My point is this: Cannot some relation be found between these various lags? Irregularities would surely be smoothed out in over fifty years' average. In the case of the eclipse, I can only put forward that it happened to be a clear day and as such would approach fairly near to an average for similar conditions if it were possible to obtain them. The rate of change of the flow of heat from the Sun is known as regards its annual and diurnal change and, taking the speed of eclipse into account, I take it the resultant rate of change could be calculated for a period during the eclipse. I suppose the earth's properties as regards radiation and absorption may be taken as constant in the three cases.

CALORIE.

210, ADELAIDE ROAD,
SOUTH HAMPSTEAD.

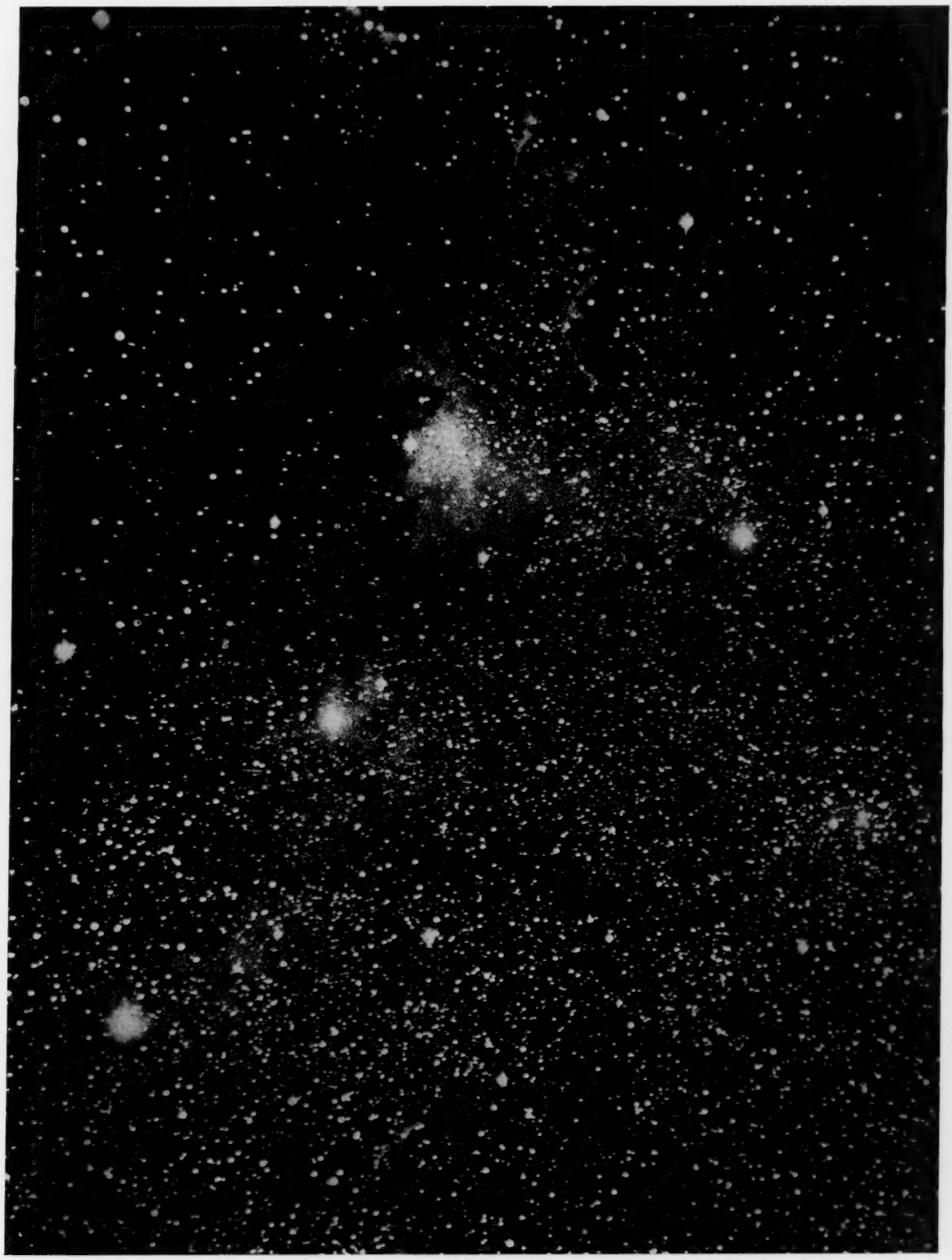


FIGURE 442.

The America Nebula (H V 37 in Cygnus).

From a photograph taken by Dr. Isaac Roberts, Crowborough, Sussex, October 10th, 1896. Exposure ninety minutes.

LIQUID CRYSTALS.

By E. JOBLING, B.Sc., A.R.C.Sc.

With illustrations from photographs kindly taken by Professor Lehmann.

WHEN it was announced more than a couple of decades ago that substances had been discovered, which, though liquid, exhibited the properties usually associated with crystals, an outburst of adverse criticism was the immediate and not surprising result. After the first stir had subsided, the attitude became one of unreasoning scepticism; the observations themselves were discredited and the disturbing conclusions calmly ignored. Time, however, has favourably modified the trend of scientific opinion, though even to-day, particularly in England, the importance of the subject is not fully realised, and, in consequence, but slight attention is devoted to it. Yet the phenomenon is such a curious and surprising one that whatever interpretation be put upon it, a brief account of its principal aspects cannot fail to be of interest.

After all, only a little consideration is sufficient to demonstrate the reasonableness of the idea of crystallinity in the liquid state. On the orthodox view, a substance which is on the point of undergoing crystallisation has its molecules moving about in the haphazard way which is characteristic of an ordinary fluid, but immediately the temperature at which crystallisation occurs is reached, these are supposed to arrange themselves in a definite order, according to the symmetry of the crystal to be formed. Such a conception, involving as it does the *sudden* formation of cosmos out of chaos, is difficult of comprehension. It must be admitted that it would be far more rational to imagine that, in a liquid as it nears the crystallisation temperature, a marshalling of the molecules is taking place which reaches its culmination at the moment of separation of the solid crystalline form. In other words, the possibility of crystallinity in the liquid state must be conceded. Let us see how far experimental evidence bears out this deduction.

EXPERIMENTAL EVIDENCE.

The discovery of liquid crystals will always be associated with the name of Lehmann, for it was he who stumbled upon the first example, and it is largely due to his persistent activity that we owe the rapid development of the subject.

In 1876, in a series of experiments with his "crystallisation-microscope," to which attention will soon be turned, Lehmann observed that silver iodide, though exhibiting a hexagonal form at the ordinary temperature, changed at 146° into a cubic modification, which was not only plastic but actually liquid. While still dubious as to the exact significance of this isolated instance, Reinitzer in 1888 drew Lehmann's attention to a substance, cholesteryl benzoate, which exhibited a double melting-point; that is to say, on heating, the solid melted at a definite temperature, and this, on further heating, suddenly clarified. The intermediate turbid phase Lehmann found to be at once mobile and doubly refractive; so that taking this in conjunction with his own example, he at once declared for the possibility of the existence of what he has called "liquid-crystals."

Since then, examples have turned up more frequently than might have been anticipated, so that there are now nearly three hundred compounds which can be brought into the same category as cholesteryl benzoate. These compounds are all organic and of very diverse structure; but instincts of compassion, as well as considerations of space, spare the infliction upon the reader of any but the simplest of the weird and wonderful names with which they have been labelled.

CRYSTALLISATION-MICROSCOPE.

Before proceeding further, some notice must be taken of the instrument to which we owe the discovery of and subsequent investigation upon "liquid-crystals."

A "crystallisation - microscope" is shown in Figure 443. The instrument consists of an ordinary microscope, which is provided with means for raising a substance to any desired temperature, for maintaining it there and for cooling it rapidly to another temperature. The heating is effected by means of a miniature Bunsen burner, A, capable of being swung into position below the centre of the stage. A delicate adjustment, B, comprising a lever moving over a graduated arc, is provided for the regulation of the height of the flame, and by the use of an air-blast, not shown in the figure, the bunsen is convertible into a blow-pipe. Also fitted to the instrument are one or more cooling-blasts, C, mounted usually upon universal joints and fitted with an arc adjustment, D, by means of which the liquid upon the slide can be lowered in temperature at almost any desired rate. It is thus possible, by a suitable combination of both heating and cooling, to conduct a microscopic examination of a substance for quite a long time at a constant temperature. In the modern complicated instruments, the arrangement of the parts is slightly different from that shown in the figure, whilst such additions as water-jackets for the lenses and electric connections on the stage are provided.

Let us now consider any one of the many well-known substances which yield "liquid-crystal" droplets and follow its behaviour under the microscope. A little of the substance—usually in some

suitable solvent in order to get isolated crystals—is placed between two cover-glasses on the microscope stage and a very gentle heat is applied by carefully regulating the height of the small bunsen flame placed in position beneath the object-glasses. When a clear melt or solution has been obtained, the bunsen is swung out of action and the air-jet then brought to bear upon the slide. In order to observe the formation and development of "liquid-crystals," it is best to rely upon their optical properties. To this end, the nicols are crossed and the field of view carefully observed. When a temperature sufficiently near the temperature of crystal formation is reached, points of light appear in different parts of the field and these gradually increase in size until discs of light are attained, in each of which black crosses can be observed. If the plate be now touched with a needle, the slight pressure is sufficient to cause distortion and as they regain their original shape when the pressure is removed, there remains little doubt as to their liquidity. The appearance of the field at this stage is that of a number of cross-imprinted discs of light resembling wheels, standing out upon a dark background. This continues until the temperature has fallen sufficiently low to have reached the temperature of transition of the liquid into the solid state; when the beautiful prismatic colours, indicative of the attainment of the latter condition, quickly make their appearance and replace the above phenomena.

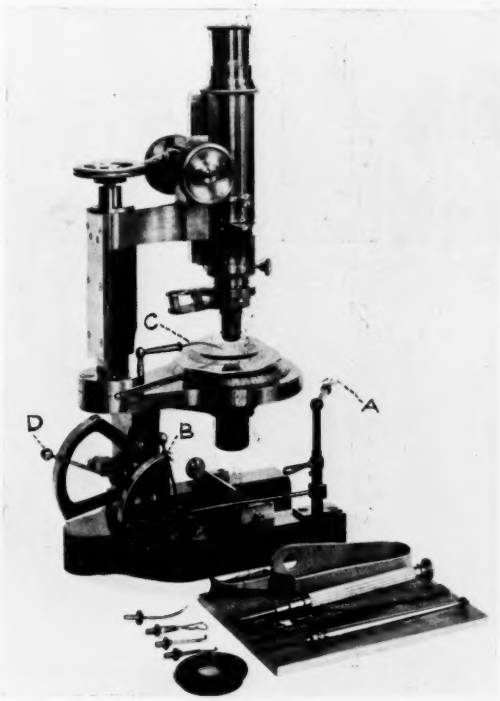


FIGURE 443.

A simple form of Crystallisation Microscope.

Figure 444 shows the appearance of the field when crystal drops of para-azoxyphenetol in olive-oil are viewed in natural light. A similar field when observed in polarised light is shown in Figure 445, where the dichröism is clearly shown, the two colours being yellow and white. The next photograph, Figure 446, illustrates fairly well the aspect of the field of the same substance as seen between crossed nicols.

A remarkable instance, worthy of special mention, is to be found in ammonium oleate, which Lehmann investigated in 1894. By crystallisation of this substance from alcohol, crystals separate which, notwithstanding their fluidity, form well-defined bi-pyramids, with edges more or less rounded. Figure 447 gives some idea of these regular shapes. That they are really liquid can be tested in the usual way by gently pressing the cover-glass. When two of the bi-pyramids approach one another, they arrange themselves at a certain angle and then slowly coalesce to form a larger single crystal. Yet another noteworthy property lies in their power of growth, since if a crystal be broken in two, each part grows again at the expense of the substance still in solution, and becomes a perfect crystal.

Figure 448 shows another instance, in this case para-azoxy benzoic acid ethyl ester, in which the crystals, though liquid, reveal a definite geometric form. The field is viewed in ordinary light and the crystals are shown in the act of flowing together.

There are even one or two exceptional instances where a substance has been discovered which exhibits a perfectly definite structure bounded by plane faces and sharp angles. In other cases, and these are now becoming quite common, dimorphism makes its appearance; that is to say, the substance exhibits two liquid-crystalline phases and therefore three definite melting-points or, more accurately, transition-points. These dimorphous phases are occasionally rendered evident by their differing degree of turbidity, though usually they are differentiated by their viscosities or other physical properties. Remarkable instances of tri- and even tetra-morphism have recently come to light; but naturally such cases are very rare.

An interesting phenomenon is to be observed when "liquid-crystals" are subjected to the influence of a magnetic field; for under these circumstances the drops rearrange themselves with their principal axes in the direction of the lines of force. This is well shown in Figures 449 and 450, where the former is a reproduction of a photograph of crystal drops of para-azoxy anisol in piperine in natural light, whilst Figure 450 represents the same drops after the magnetic field has been set up. The lines of force are in the direction of sight, and judging from the dark points which have now appeared at the centres, the drops have arranged themselves with their principal axes perpendicular to the paper.

INFLUENCE OF THE CHEMICAL CONFIGURATION.

A very noteworthy feature of the liquid-crystalline condition is that it seems to be associated almost

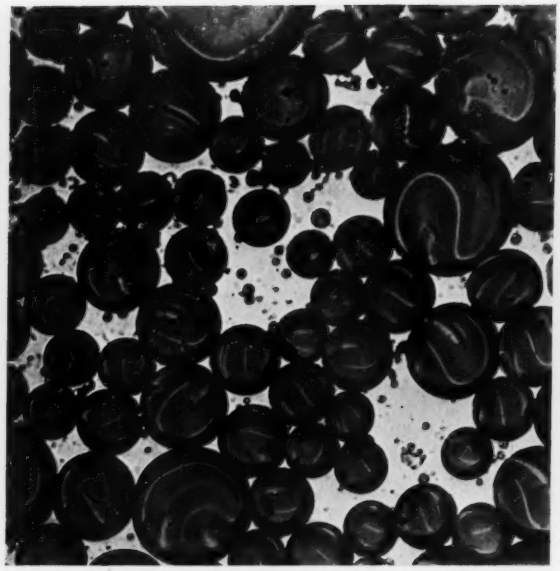


FIGURE 444. Liquid crystals of para-azoxyphenetol in natural light.

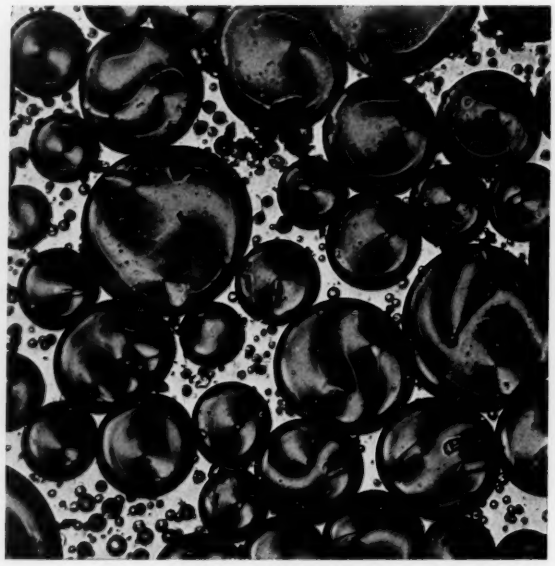
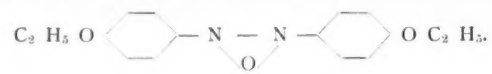


FIGURE 445. Liquid crystals of para-azoxyphenetol in polarized light.

exclusively with organic compounds and these only of a particular type. Vorländer is the investigator who has devoted special attention to this branch of the subject, having already disclosed many relationships which may have much to do with the elucidation of the phenomenon.

The general conclusion at which he has arrived is that the appearance of "liquid-crystals" is invariably associated with a linear structure of great length, that is to say, with a structure which, when represented three-dimensionally according to the modern tetrahedron arrangement of the carbon affinities, approximates as closely as possible to a straight line. The oft-recurring para-azoxyphenetol will serve as an example—



In the aliphatic division, therefore, only *normal* compounds are eligible; whilst in the aromatic series, all but *para* substituted compounds are excluded. Bending of the chain such as would be given by an ortho- or meta-compound, or the branching produced

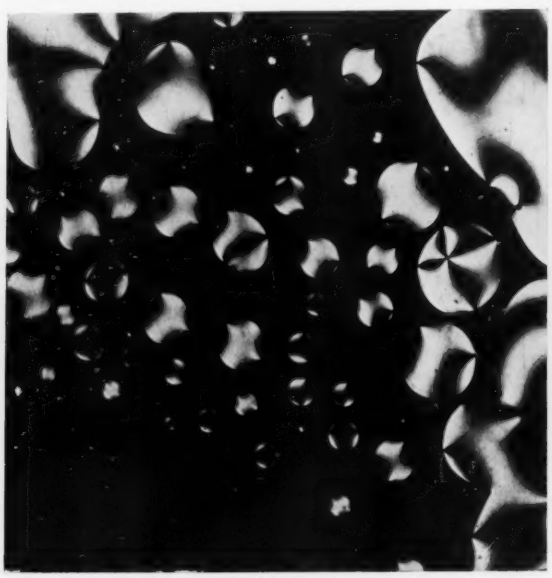


FIGURE 446. Liquid crystals of para-azoxyphenetol between crossed nicols.

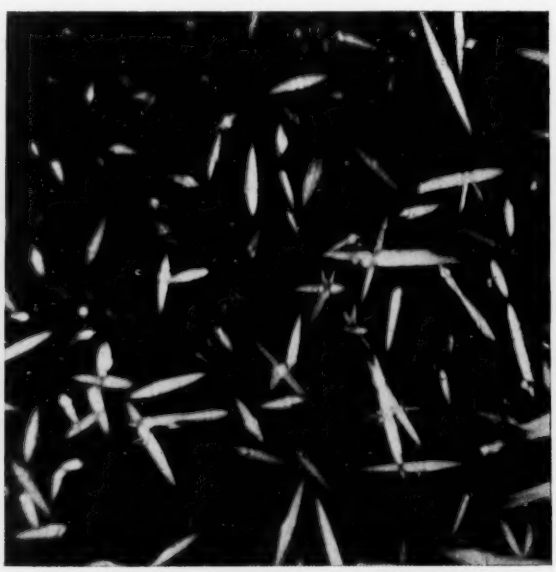


FIGURE 447. Liquid crystals of ammonium oleate between crossed nicols.

FIGURE 448. Liquid crystals of para-azoxybenzoic acid in natural light, shewing geometric form.

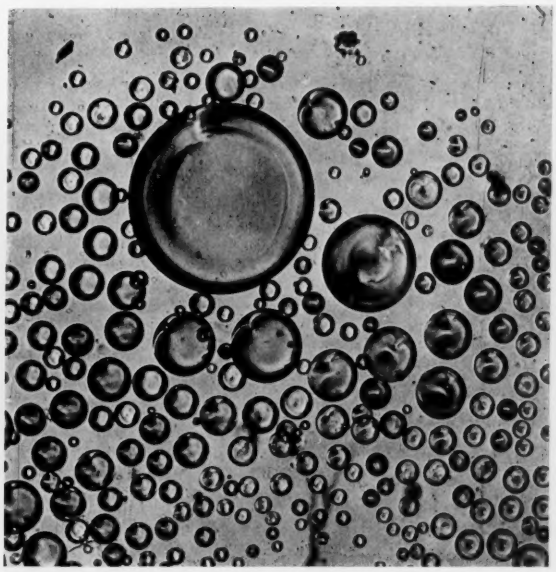


FIGURE 449. Liquid crystals of para-azoxy anisol in natural light.

by substitution, at once dispels all appearance of liquo-crystallinity.

BEARING UPON THE PROBLEM OF LIFE.

Striking similarities have recently been observed between the behaviour of "liquid-crystals" and that of the lowest living organisms. Under certain circumstances, the droplets line up in a chain resembling long fine hairs, which afford a most realistic serpentine movement. This is strikingly shown in Figure 451, where the "apparently living crystals" of para-azoxy cinnamic acid ethyl ester have been photographed in natural light. In spite of the very short time of exposure (one-fiftieth second), the indistinctness of some of the bends clearly indicates that even during this time, considerable undulations of the serpentine folds had taken place.

Add to this curious behaviour the well-known facts that crystals grow and exhibit a certain recuperative power, also that phenomena akin to auto-division and copulation are frequently to be observed among the globules of crystalline liquids, and the resemblance

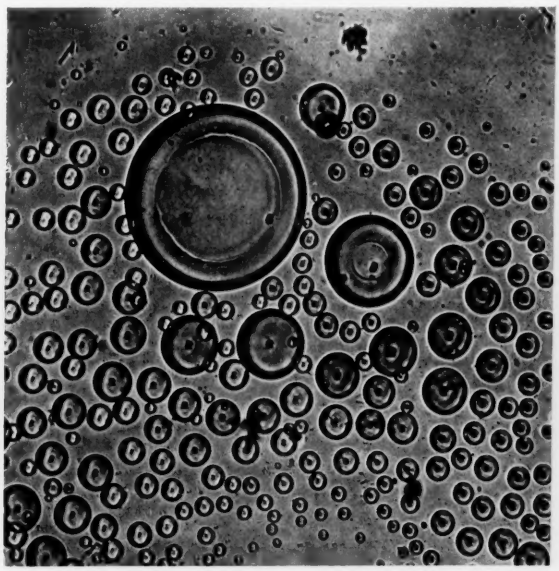


FIGURE 450. The same drop as in Figure 449, but in a magnetic field.

FIGURE 451. "Living crystals" of para-azoxy cinnamic acid ethyl ester in natural light.

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to the behaviour of the lower forms of life becomes still more complete.

To assert, however, as Lehmann has done, that living growth depends essentially upon the agency of crystallisation, is a conclusion to which all would not care to accompany him. Notwithstanding the array of evidence which he brings forward, much more research and rational consideration are necessary before anything definite can be confidently submitted. As a tentative suggestion, nevertheless, the idea is a striking one and affords an interesting contribution to modern speculation upon the origin and mechanism of life.

CONCLUSION.

The now acknowledged existence of liquo-crystalline types naturally strikes a blow at our definition of the word "crystal." Hitherto, the term has always been associated with the ideas of rigidity and solidity; but in the light of the evidence abovementioned, this old idea must be abandoned and one must admit that under certain conditions, a *liquid* may exhibit, if not always the accidental circumstance of form, at least the more important optical properties which are the outcome of a molecular arrangement. In this way, the barrier between the solid and liquid states is partially demolished.

As to what constitutes the *raison-d'être* of liquid-crystals, the hypothesis advanced by Lehmann appears to be the most likely. Especially is this the case after the failure of the ordinary theory, which attempted an explanation on the basis of a simple emulsion. Lehmann assumes the existence of some directive force, called a "configuration-determining" force, which produces a parallel arrangement of the molecules in spite of the liquid state, and each molecule of the liquid, by virtue of this force, is supposed to be striving to arrange itself as part of a spatial configuration. Vorländer's independent observations lend considerable colour to this notion. If, as he declares, all "liquid-crystal" molecules possess long chain formulae, their shape may be taken to approximate to wires or plates and these will be able to arrange themselves in some definite order. On the other hand, with molecules not so shaped, the space they occupy approximates more nearly to the spherical, and so the liquid, being only a chance aggregation of individuals, will appear isotropic. This probably explains why it is that all liquids do not display crystallinity, though their molecules may be subject to this "configuration-determining" force.

To say more of Lehmann's brilliant achievements, both experimental and theoretical, is not possible within the narrow limits of this article. But from what has been written, it will be gathered that his work constitutes a noteworthy extension of our knowledge of states of matter, particularly of the borderland between the solid and liquid states; and from the many developments which have accrued, the whole subject should be one of surpassing interest, not only to the physicist and the crystallographer, but also to the student of chemistry or of biology.

In conclusion, the author wishes to tender his best thanks to Professor Lehmann himself for the kindness he has shown in specially preparing the photographs which illustrate this article. Readers further interested in the subject are referred to Professor Lehmann's numerous published researches and to his books upon the subject, the chief of which, "Flüssige Kristalle" and "Die neue Welt der flüssigen Kristalle," are well worth consideration.

CORRESPONDENCE.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—In a letter in your issue of September, Mr. H. Stanley Redgrove states that "by the principle of the continuity of law, or the uniformity of nature . . . . the existence of a third dimension implies that of a fourth, and so on *ad infinitum*," and he argues that belief in a fourth and other dimensions is of the same nature as our belief that the sun will rise to-morrow. Our own unvarying experience of the sun rising every day, as also the unvarying experience of man throughout past ages, tells us that this is a law of nature. We believe that what has occurred in the past will occur in the future. Our experience of dimensions gives us the law that where there is one there must be three, but it gives us absolutely nothing else. There is nothing in it to lead us to believe, or even to suggest to us, that there are other dimensions. There is, consequently, no resemblance between belief in a fourth dimension and belief that the sun will rise to-morrow. Mr. Redgrove refers to detailed arguments for a fourth and other dimensions in a book which he has published. These arguments must be based not on experience but on something else. But experience—some kind of direct perception—is the only possible basis of our knowledge of what exists.

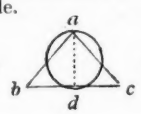
HENDON, N.W. JOHN JOHNSTON.

THE TRISECTION OF AN ANGLE.

To the Editors of "KNOWLEDGE."

SIRS,—I noticed in a recent issue of your journal a statement by one of your correspondents to the effect that a circle could not be squared by geometric methods.

Now, quite a number of years ago, I ascertained by a geometric diagram or theorem, not shown here, that the circumference of a circle is equal to the perimeter of a triangle the base and altitude of which are each equal to the diameter of the circle.

Roughly 

A D and B C equal.

This gives the ratio of the circumference of a circle to its diameter as (using five places of decimals) 3·23606.

Now, can you tell me? Has anyone stated this fact before and demonstrated it.

"GEOMA."

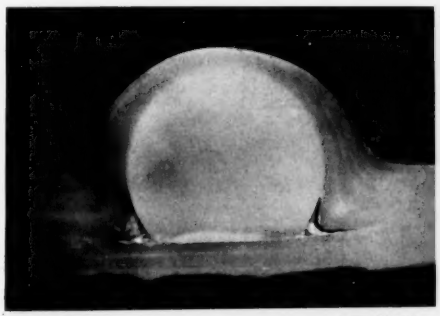
BRISBANE.

BIOLOGICAL SCIENCE AND THE PEARLING INDUSTRY.

A paper read before Section D (Zoölogy) of the British Association for the Advancement of Science at Dundee, on September 5th, 1912.

By H. LYSTER JAMESON, M.A., D.Sc., Ph.D.

In this paper I propose to review, very briefly, the more important attempts that have been made in recent years to apply the science of Marine Zoölogy to the solution of the economic problems presented by the pearl and mother-of-pearl fishing industries, in different parts of the world. The present excessively high price of pearls, and the frequent substitution for them of imitation articles, even among classes who would scorn to wear paste imitations of mineral gems, and still more the amazing price to which the best qualities of mother-of-pearl shell have risen (the best lots reached £550 per ton at the recent London sales) all emphasize the fact that, so far, we zoölogists have not been able to devise a method for increasing production, or for restoring depleted beds of pearl and mother-of-pearl oysters. And yet it cannot be said that we have been stinted for support, or that governments and financiers have in all cases turned a deaf ear to our proposals. Accordingly, while reviewing the work that has been done, I propose to set forth a few ideas, formed as a result of a study of these problems extending over some thirteen years, as to the causes of the small response Biology has made to the demands of industry in this case.



By the courtesy of E. Hopkins.

FIGURE 452.

Section of the shell of the Japanese Pearl Oyster showing a "culture pearl" attached.

The chief localities in which biologists and business men have concerned themselves with the question of the application of biological knowledge and theory to this industry are Japan, Mexico, the French possessions in the Eastern Pacific, Burma, the Red Sea, Ceylon, and Australia.

Japan.

Japan has gone ahead of all the Western nations and their colonies and possessions in being the first country to establish a pearl-farming industry, based upon a scientific knowledge of the biology and physiology of the mollusc, which has proved itself, after years of trial, to be a firmly founded and highly remunerative business. The two names which are particularly identified with the development of this industry are those of the late Professor Mitsukuri and Mr. K. Mikimoto, an ideal association of the learned scholar and the far-seeing business man. These two pioneers met first at the National Industrial Exhibition in Tokyo in 1890, where Mr. Mikimoto, a pearl merchant, had an exhibit of pearl oysters (*Margaritifera martensii*) from Japanese waters. It was then that Professor Mitsukuri suggested to Mr. Mikimoto the possibility of cultivating the pearl oysters and making them produce pearls.

When Mr. Mikimoto started practical work on the Shima fisheries, he shared the common fate of prophets and pioneers, and was ridiculed by his friends for "throwing his money into the sea." However, meeting and overcoming, one after another, the difficulties that are inseparable from the early stages of such an enterprise, turning for advice to Professor Mitsukuri and Dr. Kishinoue, retaining unshaken his faith in the ultimate attainment of his goal, he saw, within six years of his first meeting with the Professor, his enterprise pass from the experimental to the commercial scale, patented his process, and, at the end of 1898, marketed his first crop of "Culture-Pearls," as these products were named.

The enterprise is carried on in the Bay of Agu, in the province of Shima, and the area leased for that purpose, which amounted to about five hundred acres in 1904, one thousand acres in 1905, is stated to have been extended in 1911 to about twenty-two nautical miles. In 1911 it supported fifty families, whose headquarters is a village situated on a previously uninhabited island.

The operations consist in collecting the young oysters on stones, which are laid down, just before the ascertained spatting season, in areas where there is an abundant spatfall; in laying out the young oysters so collected on more suitable grounds, and, when they have attained a certain size, in operating on them to induce them to produce pearl-like excrescences or blisters. This is done by introducing between the body of the oyster and the shell a bead of mother-of-pearl, which, in the course of time (four years in Japan) becomes coated over with nacre, giving a hemispherical or more

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than hemispherical pearl-like body, or "Culture-Pearl."

In 1905 the number of oysters operated on per year was from two hundred and fifty thousand to three hundred thousand; but I fancy it is very much larger now. These blisters are used in cheap jewellery for purposes to which half pearls are applicable. I have not figures as to the present production, but it must be very large, as they are becoming extremely common in rings, scarf-pins, studs, and so on in Europe. They are not *pearls*, but *blisters*, and as such their value is small compared with that of real pearls of comparable size. Indeed, their low value leads me to think that it would scarcely be worth attempting to produce them in the majority of British pearl-shell producing colonies, where the labour and other conditions are difficult compared with Japan. There is every reason to think that Saville-Kent's enterprise with *Margaritifera maxima* in Torres Straits, though the production of "pearls" was spoken of, was in reality concerned with producing these "blisters." It has been shown over and over again that *Margaritifera maxima* and other species can be successfully treated after the Japanese method, and it may be added that in the case of *M. maxima* and *M. margaritifera* the growth of the shell is so rapid that the blisters can be produced in a fraction of the time that is required in the case of the Japanese oyster. I am informed that blisters produced in this way in *M. maxima* are being marketed now, in Paris and the United States. Although it has been stated that fancy prices have been given for a few of these, I believe their value will fall to a level comparable to the price of the Japanese article, as soon as their nature is understood by the public; and their production will, in consequence, be found to be unprofitable in the majority of cases.

It is, however, worth while considering whether it would not be practicable (provided conservation was possible) to establish a "Culture-Pearl" industry in some of the rivers frequented by the freshwater pearl mussel in these islands; if, as is possible, there are still areas where all desire for rural home industries has not yet disappeared. The practicability of producing fine blisters in our freshwater pearl mussel was proved by Linnaeus, whose specimens can still be seen at the Linnean Society, including some that are in no way inferior to the Japanese ones. I do not wish to convey the impression that we have here the potentiality of a highly lucrative industry, in which fortunes can be made, but I think the widely-spreading habit of wearing imitation jewellery affords an ample guarantee of a steady market for a product which occupies a position intermediate between the real pearl and the glass and paste imitation, and which, consequently, will meet the needs of those who cannot afford to buy the former, and whose self-respect forbids them to wear the latter.

Most of the people who have produced blisters in this way have hoped to obtain real spherical "pearls" by the same method, or a modification of it. Quite recently Mr. Toyozo Kobayashi, Professor at the Tokyo Higher Technical College, who is associated with Mr. Mikimoto in his enterprise, has informed me that Mr. Mikimoto has produced a few perfectly free spherical pearls in this way, but that the process is too uncertain to be applicable, as yet, on a commercial scale.

I have always held that a modification of the Japanese process could be devised that would yield this result. But I maintain, in view of what is known of the nature of real pearls, that such bodies would not be "pearls" in the strict sense, and I am of opinion that they could be distinguished from the real article. In fact, I doubt very much whether they could legally be marketed as "pearls."

MEXICO.

For many years past work has been carried on with a view to the cultivation of the pearl oyster of the Pacific Coast of America, *Margaritifera margaritifera* var. *mazatlanica*, in the Gulf of California; but unfortunately no satisfactory scientific account of these operations is in existence. The chief company concerned with this enterprise is the "Compania Criadora de Concha y Perla de la Baja California" and the work was initiated by Mr. Gaston Vives, who has been studying the subject for many years. The chief work of the company is transplantation, in which considerable success is claimed, and it appears that elaborate devices are used to protect the young oysters during the early attached stages, on lines not unlike those adopted for the same purpose with the edible oyster in Holland. Efforts have also, apparently, been made to propagate the oysters; but I am not aware that this has proved feasible on a commercial scale.

So far as I know, apart from transplantation, the work has not yet reached the stage which would warrant its being called a commercial success. In 1909 no less than thirty thousand pounds had been spent on the enterprise.

BURMA.

In 1907, when there was a boom in scientific work, owing to the successful promotion and large initial dividend of the Ceylon Company of Pearl Fishers, Professor Herdman was approached by the Burma Government with a view to a biological enquiry there. Professor Herdman assigned the work to two young biologists, who proceeded to Burma and published a report, which, considering the limited time at their disposal, is an excellent survey of the situation.

No very definite proposals were made for applying biological science with a view to increasing production; but the question of the repopulation of the banks was discussed on pages 18-19, and it was suggested that breeding stock should be laid down

in a sheltered bay, and the young collected. The objection to this proposal is the impossibility, in almost every case, of securing that the spat, which passes through a fairly long plankton stage in waters where there is often a strong tidal current, will return to the neighbourhood of the parent shells to attach itself.

I must here mention a matter which is regrettable. It is an instance where a regulation has apparently been based upon a scientific theory which is probably erroneous, and consequently the regulation instead of being beneficial is, if anything, harmful. In the " Rules for Lower Burma, under the Burma Fisheries Act, 1905," Sections 64 and 67, the taking of the oyster-eating fishes, *Balistes* and *Trygon* in the pearl fishery districts was prohibited, and fishermen were required, if they caught these fishes accidentally, to return them to the sea. These rules were issued in August, 1907, just after the above-mentioned report was published. They have since been repealed. It is only fair to the authors to say that the recommendation that such a regulation should be framed is not contained in their report; indeed, it is difficult to imagine how and by whom such a recommendation could have been made. At that time these fishes were supposed to harbour the intermediate and adult stages of a worm which was supposed to cause the formation of pearls in the Ceylon pearl oyster, *Margaritifera vulgaris*, but I do not think there was any evidence that the same parasite occurred in the widely different Mergui mother-of-pearl shell, *Margaritifera maxima*. And my subsequent researches have shown that, apart from this rash analogy, the idea that this worm causes pearls even in the Ceylon oyster is highly doubtful. The regulation thus had the effect of protecting what are probably two of the worst enemies of the oyster.

Mr. John I. Solomon, who is not a trained biologist but an engineer, has formed the Burma Shell Company, and started work in the Mergui Archipelago. An attempt was made by him to grow mother-of-pearl oysters in a large tank on the shore of an island; but this was, as might have been expected, unsuccessful. Some success has, however, been achieved in producing blisters on lines similar to those followed in Japan. I have seen some of Mr. Solomon's products, and they are the finest artificially-produced blisters that I have yet met with, and I understand that he is now marketing them; but whether the enterprise will prove commercially successful will depend, in the main, on whether it will be feasible in those waters to produce these commodities at a profit when they fall to a value comparable to that of the Japanese article, as they must do as soon as their nature is understood.

RED SEA.

For some years Mr. Cyril Crossland has been experimenting in the Red Sea for the Sudan Government, studying the marine biology of its waters, with special reference to the three species of Margaritifera that occur therein, *viz.*, *M. margaritifera* var. *erythreae*, *M. vulgaris*, and the valueless *M. mauritii*. So far as I know, Mr. Crossland has not yet published an account of his economic work.

FRENCH PACIFIC.

The question of cultivating the " Tahiti " mother-of-pearl oyster (*M. margaritifera* var. *cumingii*) has often been broached, and has been the subject of several scientific missions; but without any considerable results.

Space forbids me to deal with the several missions in detail in this paper.

CEYLON.

My account of the scientific work done here in the last dozen years will be very brief, as I have already dealt with it recently in two papers (*Journal of Economic Biology*, February, 1912, pages 10–22, and *Proceedings of the Zoölogical Society*, 1912, pages 260–358, plates XXXIII, XLVII).

The history of the enterprise is briefly as follows. In 1900, the Ceylon Government, anxious to devise measures for preventing the frequent occurrence of barren years or periods of years, approached the Council of the Royal Society and Professor (now Sir) Ray Lankester, with a view to obtaining scientific advice. As a result, Professor Herdman was sent on a mission to Ceylon, and left behind him, after a couple of month's work on the spot, an assistant to carry on the work initiated by him. Later on the work started by the Government was taken over by the Ceylon Company of Pearl Fishers, Ltd., a company formed largely to give effect to the recommendations made as a result of this mission. The capital of the Company was £165,000, and Sir West Ridgeway, who was Governor of Ceylon when the mission was undertaken, became chairman of the Company. Professor Herdman was retained as scientific adviser to the Company. Briefly summarised the position may be stated as follows:—The two remedies recommended as a result of the scientific mission, *viz.*, cultching and transplantation, have so far failed in practice, and the Company is now in liquidation. Moreover, as I have shown elsewhere, the most important scientific discovery claimed, that is to say, the Cestode origin of pearls, is probably a mistake. Extensive faunistic data were collected; but the relation of some of these to the main question is far from obvious.

A speech made by Sir West Ridgeway, on October 27th, 1900, after a paper by the late Mr. Oliver Collett, on Pearl Oysters, read before the Colombo Branch of the Royal Asiatic Society and reported in *The Ceylon Observer* for October 29th, suggested that Sir Ray Lankester saw, in Ceylon's need for scientific guidance, an opportunity for " enriching the scientific world at the cost of Ceylon "; a charge which is all the more unfortunate because probably a more intensive study of the pearl oyster itself, and of pearl production, would have yielded more

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immediate practical benefit than the very extensive survey of the marine fauna of Ceylonese waters which forms so large a part of the work which has been done.

A remarkable point in connection with this scientific mission was the fact that (except that I myself was invited by Professor Herdman to accompany him as assistant), no serious attempt was made, so far as I know, to secure the co-operation, even in a purely critical and advisory capacity, of the several naturalists (foremost among whom was the late Mr. Saville-Kent) who had already studied the problems connected with pearl oysters and pearls. It is, indeed, implied in a letter from Mr. Saville-Kent published in *The Ceylon Observer* of December 28th, 1900, and in a leading article of the same date, that he was deliberately left out of the councils.

I think that almost every incident in connection with the Ceylon affair, which might be used for the purpose of discrediting zoölogical work, could have been avoided if the assistance of specialists had been invoked.

Turning now to the attitude of the scientific press, I think it is to be regretted that an attempt was made to claim, as due to biological work, certain results that were the result of quite other causes. In *Nature* for July 18th, 1907, there is a review of Professor Herdman's report* in which it is implied that the phenomenal success of the four fisheries which followed upon his visit was due to his scientific investigations. On page 271 there is the following statement:

"It is very interesting to find that since Professor Herdman's expedition there have been four successive fat years of pearl fishing—the most profitable, so far as is known, that have ever been. . . . . This should surely convince the Philistines that there is something in biology after all!"

and on page 272, with reference to some observations of Professor Herdman's as to the interrelation of biological phenomena:

"If this wise saying were as widely accepted as it is certainly true, biological science would find more generous public support, and we should hear no more of impatient criticisms of scientific investigations which do not yield an increase of rupees so rapidly as Professor Herdman's study of the Ceylonese Oyster Beds has done."

I am sure that Professor Herdman would be the first to disclaim this; these fisheries, like previous ones, were the result of natural deposits of oysters, which matured, were discovered in the course of inspection, and were fished when ripe. It is particularly regrettable, in view of the heavy losses which have been incurred by the investing public through the failure of a company which hoped to achieve great results through the aid of science, that an erroneous idea of this kind should have been circulated by a paper of the standing of *Nature*. The other extreme has been reached by the general public, as instanced in the newspaper reports of the meetings of the Company, where the failure of the operations is attributed to the bankruptcy of science, a charge as untrue as it is unjust.

AUSTRALIA.—(1) MR. SAVILLE-KENT'S EARLY WORK.

The first naturalist to make a serious study of the Australian mother-of-pearl oyster (*M. maxima*), the most valuable of all kinds, was the late Mr. Saville-Kent. Mr. Kent demonstrated the feasibility of transplanting this species from the fishing grounds, and of successfully laying it down in shallow inshore waters.

His results in actual cultivation are vitiated by the fact that he mistook the "bastard shells" (*M. vulgaris* and *M. sugillata*) (see Figures 453 and 454) which can be collected in enormous quantities on suitable catchment in tropical Australia, for the young of *M. maxima* (see Figure 457). This mistake has been made by almost all investigators of this species. The young shells figured by him in his works, "The Great Barrier Reef" and "The Naturalist in Australia," are certainly "bastard shells" and not the young of *M. maxima*.

Mr. Saville-Kent urged the establishment of cultivation on the foreshore, undersized shell being brought in from the grounds and laid down to grow and reproduce. He considered such a stock would breed and multiply; but I have always held that the man who lays down breeding stock, while no doubt a public benefactor, reaps a very small fragment of the harvest himself, the free-swimming young being scattered far and wide before they settle.

In 1894, when the pioneer shellers who worked the industry from "stations" or homesteads scattered about on the various islands were giving place to highly organised fleets, owned by companies in Sydney and Brisbane, some of the shellers themselves tried to induce the Queensland Government to make the bringing in and laying down of small shell compulsory, with a view to founding a permanent white men's industry; but without results.

Mr. Saville-Kent made some experiments in Western Australia in transplanting shell, and he demonstrated that this species could be kept alive so far away from its natural haunts as Shark's Bay. He claims to have bred young oysters from stock he laid down in a mangrove swamp in Roebuck Bay, and figures in his "Naturalist in Australia" the adult shell, with the supposed young attached; but here again the "young" is really another species, *M. sugillata* or *M. carcharianum*, and the assumption that reproduction had taken place was therefore unfounded. In fact, it would seem as if Mr. Kent's oysters had provided the only suitable catchment for some of the larvae of the bastard shell, that happened to pass that way. It would have been strange if the spat produced by these few oysters in this mangrove swamp, through which the tide regularly ebbs and flows, could have found their way back to their parents, after drifting about for days, or perhaps weeks, at the mercy of the tide. I am surprised that biologists and practical shellers have so often based their hopes on this assumption.

* "Report to the Government of Ceylon on the Pearl Oyster Fisheries of Manaar." London: Published by Royal Society, 1903–6.

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FIGURE 453.

"Lingah" shell (*M. vulgaris* Schumacher), from Torres Straits.

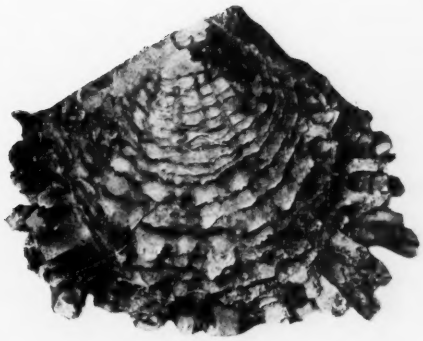

FIGURE 455.

Young of the Black-lipped Mother-of-Pearl Oyster (*M. margaritifera* Linn). Conflict Atoll, Papua.

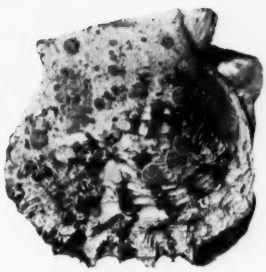

FIGURE 456.

M. panasesae Jameson. The "False Spat" that occurs associated with the Black-lipped Shell.

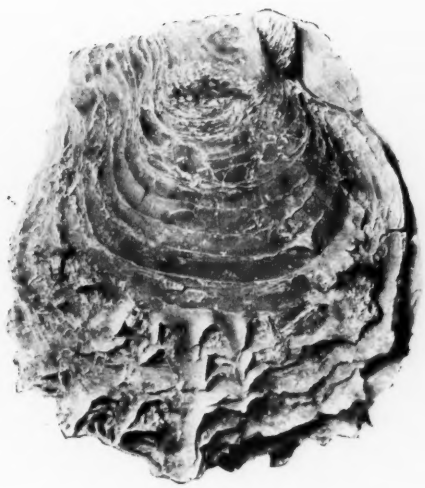

FIGURE 454.

Bastard Shell (*M. sugillata*, Reeve) from Torres Straits.

FIGURE 457.

Young of the Australian Mother-of-Pearl Oyster (*M. maxima* Jameson). Montebello Island.

From photographs specially taken and reproduced by Messrs. Lascelles & Co.

The young of Mother-of-Pearl Oysters compared with other species of the genus *Margaritifera*.

The same argument applies to Mr. Saville-Kent's claim that he got this species to breed at Shark's Bay.

As a result of his success in acclimatising the shell at Shark's Bay, Mr. Kent proposed to introduce it into Houtman's Abrolhos; but I am not aware that this was ever tried. Why people should want to try to introduce this species into extra-tropical localities, for purposes of cultivation, when there are thousands of square miles of suitable ground for this enterprise in the natural haunts of the oyster, I cannot conceive.

(2) The Pilot Cultivation Company's Enterprise in Torres Straits.

In 1891, the Queensland Legislature passed an Act permitting the taking of undersized mother-of-pearl oysters: that is to say, examples of less than five inches, nacre measurement, for cultivation purposes (this privilege has since been cancelled). The Pilot Cultivation Company was formed by some of the leading pearling-fleet owners, Mr. James Clark being the moving spirit. An area about two miles long, and varying in width from half a mile to a mile, in the passage between Prince of Wales Island and Friday Island, was leased to the Company. This passage was well known to Mr. Clark, who had formerly had a station there; so that, so far as the experience of a practical man is a guarantee, it may be assumed that it was a suitable place for this enterprise. It had formerly carried rich deposits of shell, which, however, had been cleared off.

The following account of the enterprise is in great part pieced together from what was told me when I visited Torres Straits in 1900, and from the evidence given before the several commissions on the pearling industry. It is difficult to get accurate information, or exact data; indeed, it seems probable that there was some intentional reticence on the part of those witnesses who were personally interested in the venture.

The first attempts at transplanting oysters were made with a sailing vessel, and were not successful, owing to heavy losses, attributed to insufficient circulation of water in the well in which the shells were carried; but with the substitution of steam for sailing power this difficulty was overcome. The oysters were carried on trays in the hold, and the water was kept in circulation by a powerful pump. The loss in transit was estimated to be not more than two and a half per cent., except where delays occurred or the shells were overcrowded on the trays.

I have been unable to obtain exact dates and figures; but it appears that the laying down of shell began in earnest in May, 1894, and from that date something between one hundred thousand and one hundred and fifty thousand young shells, from the area known as the Old Grounds, collected by the divers in the ordinary course of their fishing operations, were laid down. Most of them were under five inches in nacre measurement. It appears from the evidence of a diver employed in the operations that the transplanted shells were simply dumped overboard on the leased area, and no care was taken to lay them down in suitable positions. This procedure cannot be recommended to future cultivators. The shells so laid down were inspected periodically. A lot of dead ones were found, especially among those that had happened to fall on unsuitable ground. The numbers that died ran into many thousands, and it appears that twenty-four cases (about three tons) of dead shell were collected in the course of the experiment.

In August and September, 1897, seven weeks were devoted to fishing these oysters, and thirty thousand or thirty-five thousand were taken up; those marketed exceeded six and a half inches nacre measurement (one thousand four hundred to the ton). As in other cultivation experiments, high hopes were raised by the appearance of quantities of what seemed to be young mother-of-pearl oysters, on the leased area; but these proved to be bastard shell.

A few oysters were left on the ground. I have in my collection one that was taken up in 1900 when I was in Torres Straits.

The law afforded the Company insufficient protection, it being found that it was impossible to convict poachers; the court holding that pearl oysters were *ferae naturae*, a defect which has, I believe, since been remedied in the criminal code.

About the beginning of 1897 the Company introduced a biologist, Mr. S. Pace, who had been trained under the late Professor Howes, at the Royal College of Science. Mr. Pace had had no previous experience of pearl or mother-of-pearl oysters. At first he was engaged in investigations at Goode Island, but subsequently he took up his quarters on the hulk "Dayspring," a vessel which, beginning as a missionary barquentine, had had a highly chequered career before she was moored in Friday Island Passage, as a floating biological laboratory. Mr. Pace has never published an account of his work; but it appears from evidence laid before the Commissions by his employers that such results as he achieved were of academic rather than practical value.

In a report published in the Thursday Island Government Resident's Report for 1898, Mr. Pace proposed the construction of a tank or incubator, perhaps by damming the ends of a channel, in which hand-fertilized ova were to be carried through the pelagic stage, and caught on collectors. Paper anticipations of this kind are common in connection with proposals for the cultivation of mother-of-pearl oysters and edible oysters, but the practical success of such devices has yet to be demonstrated.

With regard to the cost of the Pilot Cultivation Company's enterprise, it is difficult to get anything like satisfactory figures. It is generally claimed by those who carried through the work that it meant a heavy loss to them, and this may be so, if futile experiments and scientific work carried on for an insufficient period be debited against the returns

But, it is probable that the actual cost of collecting, transplanting and raising the shell was considerably more than covered by the price realised by sales.

The work done by this company can hardly be called cultivation. It was simply removing young and undersized shell from the natural grounds and laying them down in more sheltered waters, in order that when they had grown to a profitable size or to a size at which they could be marketed without infringing regulations, they might be economically harvested. As to the scientific investigations, it was absurd to imagine that the problems could be solved in a couple of years by a young naturalist, fresh from college and without previous experience. If success could be achieved so easily as this the prospects of this industry would indeed be alluring!

(3) My Experiments in Papua, in 1899–1900.

From November, 1899, to August, 1900, I was engaged by the lessees of the Conflict Atoll in experimenting with a view to the cultivation of the black-edged mother-of-pearl oyster, *M. margaritifera*, and the introduction into the lagoon of the large mother-of-pearl oyster, *M. maxima*, which occurs around the mainland and larger islands. In the case of the former species, the difficulty centred around the impracticability of obtaining spat in sufficient quantities, the great bulk of the supposed spat obtained on collectors proving to be a worthless species, *M. panasesae*. With regard to *M. maxima*, it does not, in my experience, frequent pure atoll formations, its occurrence in Eastern British New Guinea being confined to the neighbourhood of the mainland, and of those islands which are of a formation other than recent coral.

Several consignments of this species were laid down. Attempts to secure spat from them were not successful, and, while my observations did not extend over a sufficient period to warrant a dogmatic statement, all the indications point to the conclusion that proposals to establish this species in atoll formations, where it is not native, are not likely to meet with success, and I urged strongly at the time that, if the cultivation of this species was to be undertaken seriously, a suitable site on its native grounds should be secured.

The apparent unsuitability of atoll lagoons for this species is perhaps associated with the higher salinity of the water, and the absence of river influence; for my studies lead me to believe that, while an excess of fresh water is injurious to this species, it normally frequents localities where the water is, occasionally or regularly, influenced by minute traces of river water and the detritus which it carries with it.

(4) Mr. J. R. Tosh's Work for the Queensland Government.

Mr. Tosh, who had been trained under Professor M'Intosh, at St. Andrew's University, went out in June, 1900, and made Thursday Island his headquarters. There is practically no published record of what he achieved, and there is some reason to think he received inadequate support from the Government. He and I laid down a few young pearl oysters at Badu, in September 1900, with a view to obtaining growth data; but I do not think that these were ever recovered. In 1901, he made proposals for the erection of a laboratory and "hatchery" at Wai Weer, a small island about two miles distant from Thursday Island; but effect was not given to his proposal, although I believe tenders were called for. The laboratory was to include three concrete tanks for experimental work (see note by Professor M'Intosh, in *Nature*, August 15th, 1901), and it is probable that these constituted the "hatchery"—another of the many barren proposals to raise oysters in tanks. Mr. Tosh published a report, of a purely administrative nature, in the Report of the Queensland Marine Department for 1900–1901. The principal recommendations were the closing and opening of the grounds in rotation, as is done in the French Pacific, the gradual reduction of the number of boats licensed, and the raising of the size limit to six inches. He also advocated the adoption of the six-inch limit for the black-lipped shell, which to anyone familiar with that species in Queensland waters will appear quite absurd.

Mr. Millman, the Government Resident at Thursday Island, in his Report for the year 1904, stated that Mr. Tosh "by actual experiment arrived at the knowledge that, given suitable tanks or docks, something like seventy-five per cent. of the enormous number of spat might be saved, and would on removal to proper beds arrive at maturity." If Mr. Tosh achieved this result he has done what practically all other experimenters have failed to do with this and other species, despite many and elaborate experiments. Mr. Millman goes on to say that Mr. Tosh's services were "dispensed with at a time when he was about to fully demonstrate the method of securing and saving the spat emitted in such enormous numbers." It appears in Mr. Millman's report that it was proposed to raise spat in the hatchery at Wai Weer, and to sell the young shell, at six months old, to cultivators, to be laid down on their concessions till it should reach a marketable size. The artificial production of "pearls," apparently on the Japanese lines, was also a part of the scheme, as outlined by Mr. Millman. Mr. Millman also made the statement (I do not know on what authority) that the oyster changes its sex every year; this I believe to be unfounded.

(5) Mr. Saville-Kent's Enterprise in 1908.

About the year 1906 Mr. Saville-Kent obtained a concession for cultivation purposes near Somerset, in Torres Straits, and shortly afterwards formed the Natural Pearl Shell Cultivation Company, Limited,

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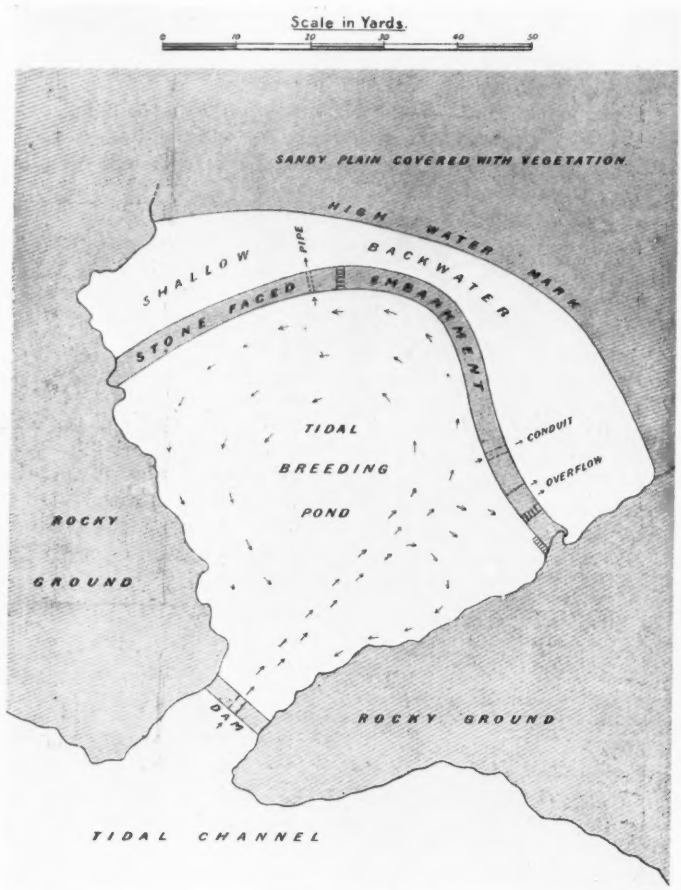
to carry on the cultivation of mother-of-pearl oysters, and the forced production of pearls, according to a "secret process" which he claimed to possess. Mr. Kent treated some oysters for pearl production in December, 1907, and the more extensive work appears to have commenced in February, 1908. Spat collectors were laid down, and quantities of spat were collected, which were, in all probability, only the valueless "bastard" shell. Between May and July of the same year about two thousand oysters were laid down, apparently as breeding stock, with a view to collecting the spat produced by them, on the grounds. This has often been done, and has been taken up by scientific men, who ought to know that it is a forlorn hope. Laying down breeding stock has much to be said in its favour in certain cases where the edible oyster is concerned, especially if the beds are in land-locked waters, where there is little chance of the spat being swept away by the tide; but it is too much to expect that any appreciable percentage of the larvae of the mother-of-pearl oyster, which lives a pelagic life lasting for some days, if not weeks, and which occurs in places where the tidal currents are frequently five knots or more, would return to settle alongside their parents. Of course, the establishment of State breeding reserves, which Mr. Kent advocated in a Report to the Queensland Government in 1905, is quite a different matter, and merits attention.



By the courtesy FIGURE 458. *of T. H. Haynes.*

Plan of Tidal Pond, showing the course of the current.

Breeding tanks were also installed, presumably with a view to rearing larvae through the pelagic stage. I have already said that this is a project that has never been successfully realized, and proposals of this kind should now cease to be taken seriously, until at least experimental results have been demonstrated.

It appears that the production of so-called "pearls" was the chief object of this Company. The process for producing these was kept a secret, and I believe the documents relating thereto are still in the possession of the successors of the Company. There is, however, good reason for believing that the process was analogous to the Japanese and Linnean processes.

The "pearls" figured in the appendix to the Report of the Queensland Pearl Shelling Commission (1908), and those figured by Saville-Kent in "The Great Barrier Reef," and "The Naturalist in Australia" certainly were. Mr. Saville-Kent once showed me some of these so-called "pearls." I have already given my opinion on the value of such blisters in the beginning of this paper. Their production on a commercial scale in Queensland would, I think, at the best be only practicable as an unimportant adjunct to the cultivation industry.

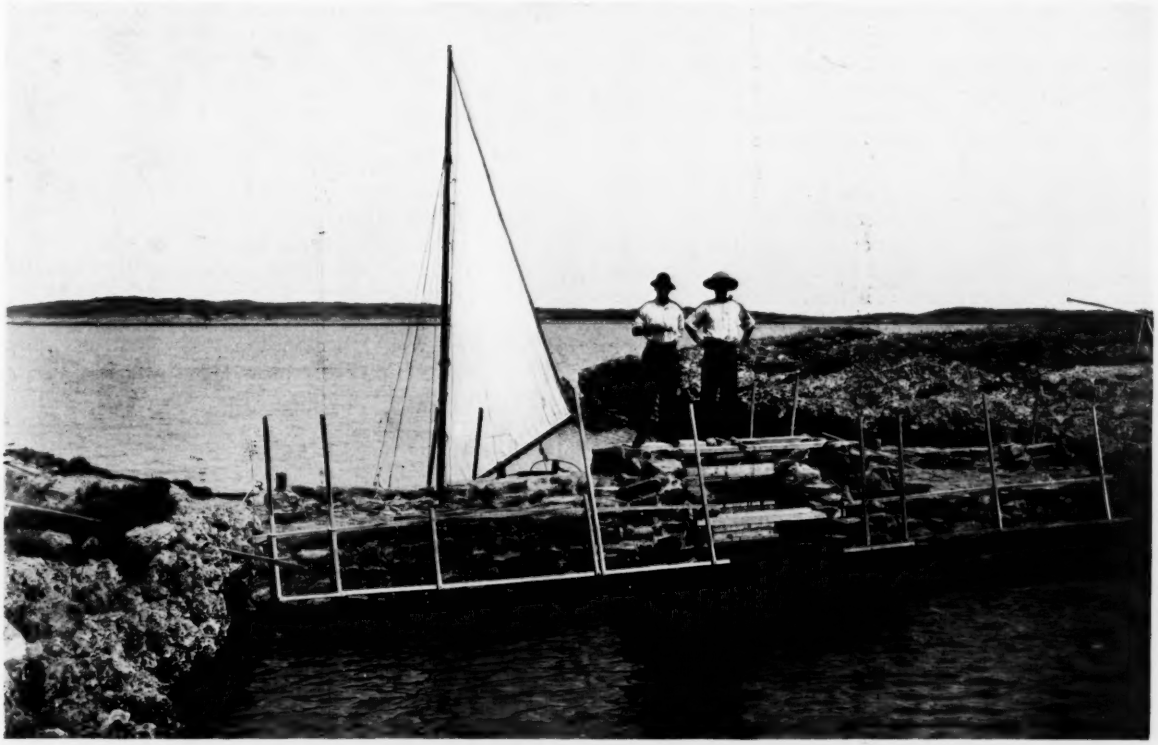
The weak points in this enterprise seem to have been the supposition that the "bastard" shell was the young of the mother-of-pearl oyster; the too-sanguine assumption that the latter could be bred in tanks; and the confusion between "blisters" and "pearls." The lease was much too short, and the law did not provide satisfactory redress against trespassers. The lease was abandoned in 1909, owing to Mr. Kent's death. Mr. Kent had also some concessions in the waters between Borneo and the Malay Peninsula; but I am not aware that they were developed.

(6) MR. T. H. HAYNES' EXPERIMENTS IN NORTH WEST AUSTRALIA.

In 1902, Mr. T. H. Haynes, an experienced pearl-sheller in Western Australia and the East Indies, obtained a concession covering the Montebello Islands, a well-known locality for *M. maxima*. At first he carried on the work as a private concern, but

in 1909 the latter was taken over by a syndicate, the Montebello Shell Syndicate, Ltd. The first season in which work was carried on was 1904. A tidal pond, an acre in extent, was made by closing a natural bay with a wall and sluice. (See Figures 458 and 459.) The pond could be emptied by specially constructed syphons. Between two hundred and three hundred shell were laid down in this pond, as breeding stock, and they throve well. No young shell appeared in the pond. Catchment of various kinds was provided. Examples from the breeding stock were examined from time to time, and the maturation of the gonads tested.

Young oysters, of a kind, appeared. The first were seen nineteen days after the breeding stock were laid down; a few were as much as one-eighth of an inch in diameter. These and subsequent deposits of young oysters all died off. It is not possible to say whether they were produced by the oysters in the pond, or whether they were "bastard"



By the courtesy FIGURE 459. A view of the Tidal Pond Dam. *of T. H. Haynes.*

Further experiments were made in 1909–10; but with inconclusive results.

A third and more elaborate experiment was made in the season 1910-11. The particulars of this experiment, given below, were supplied to me by Mr. Haynes. Mr. Haynes had determined that in these waters the spatting season is between October and April. A breeding stock was provided consisting of oysters which had been acclimatised to the waters before the previous season. They were ascertained to have maturing gonads in November, 1910.

As a preliminary to the experiment the pond was emptied, and all fish ejected. Between three hundred and four hundred breeding oysters were introduced. The pond was closed, and the only change of water occurred by the falling of the level some nine inches on the ebb owing to percolation through the bottom, and by the restoration of an equal amount through the sluice on the flood-tide. shell, introduced in the water at flood tide. Mr. Haynes thinks they were young *M. maxima*, produced by his breeding stock, and it appears from a Report by him (Mother-of-pearl Shell Culture, Report to the Directors of the Montebello Shell Syndicate, Ltd., London, 1912) that Mr. Dannevig, the Commonwealth Fisheries Officer, was inclined to share his view; but I am unable to agree with him, though not denying the possibility of his contention. Of course, without specimens it is useless to discuss what species they were; indeed, I know of no character which will allow of the identity of a species of *Margaritifera* being safely diagnosed, at so small a size. There is not, however, satisfactory proof that the breeding stock emitted spawn in the pond, and there is reason to think that at the close of the experiment they had not yet done so. And, although enough is not known of the duration of the free-swimming stage of this species to allow me to say whether the spat found nineteen days after the

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beginning of the experiment could have been produced in the tank, I lean to the view that this is unlikely, and that these young oysters, whatever they were, had been introduced with the water.

The experiments have for the present been abandoned. Up to date they have cost £6,800, not taking into account the personal services of Mr. Haynes.

The weak point in this work was that it was carried on without scientific assistance. While in a great many cases a scientific man, expected to undertake constructive work and to initiate operations on business lines, fails through lack of previous experience and business instinct, there can be no question that in a case like this, where initiative and resourcefulness, faith in the practicability of the enterprise, and practical and business knowledge were possessed in a marked degree by Mr. Haynes, the advice of a naturalist, concentrating his work on the practical problems which presented themselves, and refraining from dissipating his energy over the intensely fascinating field presented by an unworked tropical fauna, might have made all the difference. Indeed, I have often said to my friend Mr. Haynes that, had he and I had the luck to meet some eleven or twelve years ago, when I was in a position to undertake work of this kind, we should probably both have made our fortunes by now: or, if, as is so often the case, the originators of the enterprise had been "frozen out" and left stranded by the financial gentlemen who generally step in at a later stage, we should have, at any rate, the satisfaction of feeling that our names would go down to posterity as the founders of a new industry.

Other enterprises have been started in Australia, at Beagle Bay and elsewhere; but they have been largely empirical and are thus outside the scope of this paper.

(7) Transplantation of the Australian Mother-of-Pearl Oysters (*M. maxima*) to the Pacific.

A few years ago a Frenchman took about one hundred live mother-of-pearl oysters from Torres Straits to Noumea; but I have no knowledge what became of these.

In the year 1904 Levers Pacific Plantations, Ltd. (to which Company I am indebted for much of this information) engaged Mr. Saville-Kent and transplanted fifteen hundred examples of *M. maxima* from Torres Straits to Suwarrow Island, a distance of about three thousand miles. The transport was carried out successfully, only a small percentage being lost. The oysters were laid down in the lagoon at Suwarrow, which already contained the black-lipped species. The Secretary to the Company informs me that the oysters did not become acclimatised or increase, but gradually died out. Large quantities of small shell were reported as growing on the marine grasses at Suwarrow, but these proved to be a worthless kind, and not the young of the introduced oysters.

The failure of this experiment was only to be expected, and serves to confirm the conclusions I arrived at after my experiments in 1899-1900 at the Conflict Atoll, that this species cannot profitably be introduced into atoll lagoons far from land or river influences.

Besides these actual experiments in the acclimatisation of this species outside its natural haunts, various proposals have been made, casually or seriously. It is obvious that, if such a valuable animal as *M. maxima* could be introduced into a locality where it would become acclimatised and reproduce, it might become a very important new asset. There is no reason why there should not be localities where this species is not native, that possess the necessary conditions to enable it to be established. But, in view of the very special characters of its natural haunts, it would be necessary to treat such proposals with great caution. It appears from Mr. Haynes' report, referred to above, that at one time Mr. Crossland contemplated the introduction of twenty thousand West Australian mother-of-pearl oysters into the Red Sea. I think, however, that it is very doubtful whether this species would live in the Red Sea, where the density and salinity of the water are much higher than on its native grounds.

I understand that the introduction of this species into the West Indies has also been suggested; but it is to be hoped that before expenditure is incurred steps will be taken to obtain advice from someone competent to speak on the matter. The question of its introduction into Ceylon has also been discussed; but nothing has come of it.

When one considers the enormous potential asset that the mother-of-pearl fisheries are to Australia, scattered as they are all along her most vulnerable side, the North and North-West coasts, one is impelled to ask why more has not been done to develop them on lines which would result in the establishment of a permanent white man's industry. In the early days some of these grounds were enormously rich, carrying shell to the value of thousands of pounds to the square mile. These grounds have now been denuded, and fleets and vested interests, valued at hundreds of thousands of pounds, have been built up out of the proceeds of the exploitation of this natural wealth. The industry is now languishing, and is merely an asset for the Japanese and other aliens, save for a margin of profit made by the Europeans, who still finance and nominally control it.

One cannot but ask why Australian statesmen, so far-seeing where other kindred matters of policy are concerned, have not yet seriously invoked the aid of science. I think the reasons are probably twofold. Firstly, there is the effect such a change would have on existing vested interests. There can be no denying that any attempt to initiate conservation and cultivation would be most unwelcome to the present fleet owners, as it would certainly entail the

closing of considerable areas of the grounds, and the substitution of individual for common rights thereon. Moreover, the success on any considerable scale of cultivation would be a severe blow to those whose money is invested in the industry as at present carried on, and who would be faced with the necessity of writing off large losses. Secondly, Australians, like the rest of the British people, have perhaps hardly yet realised the strength of zoölogy: that is to say, the immense amount of practical and theoretical information that is available, if it can only be properly mustered and coördinated for the elucidation of their problems. Against this potential strength of our science must be set off the drawback that work of this kind has hitherto been regarded as a fit training for the young and inexperienced man of promise—a useful stepping stone to a post at home—rather than as demanding the best men the Empire can offer.

And yet, to anyone with imagination and faith in the possibilities of his subject, the Australian pearl fisheries offer work of a kind that seldom falls to the lot of a zoölogist. The man who can show how the old and formerly rich beds can be restored as an asset for the white man will be able to see, perhaps not only as a vision but as a reality, the North and North-West coasts of Australia, which are crying out for settlers, peopled with men of his own race—somewhat scattered, perhaps, but none the worse for that—drawing a part of their living from the sea, a part from the soil. To the biologist who can solve the Australian problem there is in store not only the privilege of advancing knowledge and industry but the honour of being numbered among Empire-builders.

A consideration of the small amount that we biologists have so far been able to do to improve the prospects of the pearl and mother-of-pearl fishing industries, and of the immense possibilities of these industries as a field for applied biology, leads one to enquire whether it would not be possible to devise a means for rendering our science more useful, and more directly available to those who may be disposed to invoke our aid. The following suggestion is therefore put forward, tentatively, for the consideration of those concerned with the organisation of science.

Is it not time, in view of the minute and ever-increasing specialisation of our subject, that some kind of machinery were provided that would, when required, bring together and make available for the public, whether Governments, financiers, or shareholders, the available scientific knowledge and advice, on particular subjects such as problems of economic biology? It is seldom, when a new subject like this is broached, that the information necessary to achieve practical results is all in the possession of any one man. Such machinery, if it existed, would be a most valuable asset, never more needed than now, when investors are looking further and further afield for openings for their capital.

What seems to be needed is some organising or coördinating machinery that will bring to bear on a question like this all available reputable specialist opinion that is likely to be useful, both in the preliminary stages, when a plan of campaign is being laid, and in the later phases, when examination, criticism, and correlation of results, and the formulation of a working policy, are required.

It is suggested that if such machinery existed, not only would the prospects of such missions as the Ceylon one, undertaken under the wing of a strong Government, and backed at a later stage by abundant capital, be brighter, and some of the mistakes that have undoubtedly been made in the past be almost impossible, but the public would soon begin to realise that there were available expert "Courts of Appeal" to protect administrations and investors.

Without measures for correlating and concentrating specialist knowledge, the progress of economic biology, as it becomes more and more specialized, will run a risk of being seriously impeded by difficulties similar to those which baffled the builders of the Tower of Babel.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE DISTANCE OF THE MILKY WAY.—I have followed with interest Professor Very's articles on this subject. Time does not permit me to go very fully into the discussion, but I wish to put forward a few considerations which seem to me to make so small a distance very improbable.

(1) We find that the nearer stars have *motus peculiaris* of the same order as the Sun's motion (some twelve miles per second). That the Sun's *motus peculiaris* should without any obvious reason be just the same, both in magnitude and direction, as that of the Milky Way, and that all that countless host should have practically the same motion without any sensible variations, both appear highly improbable *a priori*.

(2) It is well established, by careful counts of star density that this density steadily and continuously increases all the way from the poles of the Milky Way to the Milky Way itself; unless we assume most artificial distribution, this can only mean that the stellar system is flattened like a bun; and if the more distant region were only sixty light years, the nearer portions would be only some twenty light years away, so that all the stars near the poles of the Galaxy should have sensible parallaxes and large proper motions, which is not in accord with a superficial examination of the data.

(3) There are some seventeen stars concluded to have a parallax exceeding one-fifth of a second; that is, within a radius of fifteen light years. We may make some allowance for undetected parallaxes, but we can hardly extend the number above thirty. Taking a radius four times as great, or sixty light years, we should expect to find sixty-four times as many stars, say two thousand; but we actually find about

one thousand million stars in the sidereal system, so that we require a star density in the outer portion more than half a million times as great as in our own neighbourhood, which is certainly an improbable arrangement. Moreover, such extreme crowding would make the mutual gravitation of the galactic stars appreciable, and would render the absence of relative motion still more unlikely.

(4) The nebula round Nova Persei gives us a fairly reliable estimate of the distance of a portion of the Galaxy. We have to make two assumptions, both of which seem to me probable: (*a*) that the nebulosity was rendered visible to us by the reflection of light from the Nova; (*b*) that the Nova was really in the Galaxy, not merely between us and it; this is deducible from the fact that Novae, almost without exception, have appeared in or near the Galaxy. (I think the only exception is Nova Coronae.) It is well known that, even assuming (*a*), the distance of the Nova is not immediately deducible. This distance depends on the angle Earth-Nova-Nebula. Calling this angle ϕ, and calling α the apparent angle through which the Nebula moved outwards from the Nova in a year, a simple trigonometrical calculation gives us the distance of the Nova in light years $\frac{\sin(\alpha+\phi)}{\sin\alpha+\sin\phi-\sin(\alpha+\phi)}$

I take α, from approximate measures of the photographs of the nebula, as 14″·6, and deduce the following values of the distance in light years corresponding to different values of ϕ.

ϕ	10°	20°	30°	40°	50°	60°	70°	80°	90°	
Distance..	2736	1336	848	646	504	407	336	280	235	light years.
ϕ	100°	110°	120°	130°	140°	150°	160°	170°	—	
Distance..	197	164	135	109	85	63	41	20	—	light years.

Kapteyn, from some very probable reasoning based on the forms of the nebular outlines in the photographs, adopts 79° for ϕ (*Astro. Nach.* 3756, and *Pop. Astron.*, 1902, March). This implies a distance of two hundred and eighty-five light years, and a parallax of 0″·011. It seems highly probable that the distance of Nova Persei is not more than some four hundred light years. The small values of ϕ implied by the assumption of a greater distance would imply that the nebula did not surround the Nova, but was several light years on the near side of it, which is an artificial and unlikely configuration.

But a distance of four hundred light years for the nearer parts of the Galaxy is not inconsistent with Newcomb's estimate of three thousand light years for its further parts. It may well have several coils, and their depth in the line of sight may considerably exceed their breadth.

PHOTOGRAPHY OF THE MOON IN ULTRA-VIOLET LIGHT.—Mr. R. W. Wood has been for many years experimenting on the different results obtained in photographing the moon with light of different wave-lengths. He describes his latest results in *The Astrophysical Journal* for July. He uses a nickel-on-glass reflector, and obtains the ultra-violet images by covering the plate with a screen of uviol glass, one millimetre thick, coated with silver; this is opaque to all but ultra-violet rays. For comparison he took ordinary short exposure photographs without any screen (these are chiefly formed by violet light) and orange exposures with Cramer Iso plates and a deep orange screen. He tried the effect of making a three-colour picture from the three negatives, using red, yellow and blue pigments to represent the orange, violet and ultra-violet negatives. He states the result was "a very pretty colour photograph, which brought out the difference of reflecting power of the different maria in a very striking manner. The prevailing tone of the darker portions of the lower surface was olive green, but certain spots come out with an orange tone and others with a decided purple colour."

A remarkable spot near Aristarchus was found to be invisible in yellow light, faint in violet, very dark in ultra-violet. By experiment he found that volcanic tuff stained with sulphur gives this effect and suggests that sulphur had been deposited in that region by a volcanic blast. The new method seems to afford a lever by which, in time, considerable information may be gained as to the constitution of the Moon's surface rocks.

COMETS.—Mr. Walter F. Gale, of New South Wales, the discoverer of Comet 1894 II., found another comet on September 8th last. It has been visible to the naked eye, with a bright nucleus, a considerable coma and a short tail. Perihelion passage 1912, October 4·96, Greenwich M.T., Omega 25° 36′, Node 296° 56′, Inclination 79° 54′, Perihelion Distance 0·7164.

Ephemeris for 11 p.m.

	R.A. H. M. S.	North Decl.		R.A. H. M. S.	North Decl.
Nov. 2.—16	3 47 ...	25° 22′	Nov. 14.—16	13 25 ...	33° 25′
„ 6.—16	7 1 ...	28 8	„ 18.—16	16 29 ...	35 58
„ 10.—16	10 14 ...	30 49	„ 22.—16	19 17 ...	38 31

The Comet should be looked for in the West as soon after sunset as it is dark enough. It was visible in October in considerable twilight, but will be much fainter in November, since it is receding from both Earth and Sun.

Tuttle's Comet, whose period is thirteen and two-thirds years, comes to Perihelion about January 3rd next, and will be well placed in December.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

BEES AND GREEN FLOWERS.—As is well known, various flowers are visited by insects despite the absence of white or brightly coloured petals; in fact, some flowers in which the floral leaves are green, like the ordinary foliage-leaves, are visited by bees for pollen. Plateau and other writers on this topic have gone so far as to assert that all flowers might be as green as their leaves without their pollination being compromised. Lovell (*American Naturalist*, 1912), has made various experiments with bees and flowers, and objects to which honey had been added, and from his results concludes that (1) green flowers are not well adapted to insect pollination, many if not all such species having been derived from larger and more highly developed forms by degeneration; (2) any surface, whether bright or dull coloured, on which there is honey will be freely visited by bees after the honey has been discovered; but it will not be discovered so quickly on a surface that does not contrast in hue with its surroundings as on one which does so contrast; (3) the experiments of Plateau on green or greenish flowers are fallacious; (4) when honey-bees are given the choice between a conspicuous and an inconspicuous object under similar conditions, they show a marked preference for the former, and this preference is strong enough to account for the development of colour contrast in flowers.

LEAF-MOVEMENTS IN OXALIDACEAE.—The familiar "sleep-movements" of the leaves of Wood Sorrel and other members of the Oxalidaceae have been investigated by Pfeffer, Darwin, Sachs, and other writers. An interesting account of new experiments on these movements is given by Ulrich (*Trans. Bot. Soc. Pennsylvania*, 1911), who concludes that light plays the most important part in the normal movements of the leaflets of Oxalidaceae, heat and humidity being secondary; the leaflets reach their highest points soon after sunrise, and then sink again for a short time, the rest of the movements during the day depending upon the conditions of their environment; in darkness the movements do not cease until the leaflets have become degenerated; in blue light, leaves usually oscillate less than in white light, but in a week's time they become almost normal; electric stimulations give the most uniform results in experiments, because they can be so accurately repeated; some species assume their sleep position by a series of drops followed by partial recoveries; the rising of the leaflets in the morning is due to the stimulation of the light of the preceding day, which by its constant repetition has made these movements hereditary—they continue, when once inaugurated, in the absence of such stimulation.

XUM

SEXUALITY IN YEASTS.—As previously noted in these columns ("KNOWLEDGE," 1911, page 106), the Yeast-fungi (Saccharomycetes) have probably been derived from certain simple sac-fungi (Ascomycetes) which have a definite vegetative plant-body or mycelium consisting of filaments and in which a process of fertilisation occurs prior to the formation of the spore-fruit. Since the publication of the note referred to, several interesting new observations have been made which appear to indicate the existence of a regression series in the Yeasts, beginning with forms in which sexuality is pronounced and ending with completely sexual forms. These observations are dealt with in papers by Guillermond (*Comptes Rendus Soc. Biol.*, Paris, 1911) and by Nadson and Konokotine (*Bull. Jard. Imp. Bot.*, St. Petersburg, 1911).

In the genera *Schizosaccharomyces* and *Zygosaccharomyces* the conjugating cells are alike, and the spores produced after conjugation vary in number from two to eight. In *S. octosporus*, where eight spores (the typical number for Ascomycetes) are formed, the two conjugating cells fuse completely into an ovoid cell, but in other conjugating Yeasts belonging to these two genera the spores are fewer, and may either be all formed in one of the two copulating cells (which after union resemble two retorts with fused necks) or some in one cell and the rest in the other. In *Debaryomyces globosus* the spore-producing cell (ascus) may either arise by copulation as in *Zygosaccharomyces*, or without copulation, or by conjugation of the mother-cell with a rudimentary bud which it has previously given out and which becomes emptied back into the mother-cell. In *Schwanniomyces occidentalis* there is no copulation, but the ascus shows an outgrowth representing a conjugating tube which is functionless. In *Willia anomala* the ascus is formed at the expense of an adult cell which has absorbed the contents of a bud, smaller than the mother-cell, the latter apparently functioning as a male cell—this is similar to the third mode of ascus-formation just mentioned as sometimes occurring in *Debaryomyces*. In *Saccharomycodes Ludwigii* and *Willia Saturnus* conjugation does not take place; but during the formation and maturation of the spores within the mother-cell nuclear fusions occur, which according to Guillermond represent a delayed sexual process.

Nadson and Konokotine describe a new genus of Yeasts, *Guillermondia flavescens*, in which conjugation occurs between a smaller and a larger cell, the former having been produced as a bud by the latter, which then produces an ascus as an outgrowth; into this the contents of the "fertilised" cell pass, and a single spore is formed, or in some cases two spores.

Though the interpretation of some of these fusions is perhaps an open question, and it is doubtful whether the phenomena described can in all cases be regarded as sexual processes, these recent observations certainly strengthen the links between the Yeasts and the lower typical Ascomycetes, such as *Eremascus* and *Endomyces*, and they also appear to indicate that in the Yeasts, as in the Saprolegniaceae, we have a series of forms showing gradual loss of sexuality.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

A TOXIMETER FOR CARBON MONOXIDE.—An ingenious apparatus for detecting the presence of poisonous proportions of carbon monoxide in the atmosphere is described by M. A. Guasco in the *Comptes Rendus* (1912, CLV, 282). It is based upon the fact that when spongy platinum, or platinum black, absorbs carbon monoxide there is a decided increase of temperature. This is made apparent by means of a differential thermometer in the form of a U tube, charged to a certain height with a coloured liquid. Above this tube, and communicating with it, are two bulbs, protected from contact with the atmosphere by a surrounding vessel, but provided with porous membranes through which the gas can pass by endosmosis. One of these bulbs is coated with the platinum black, and any alterations in the temperature produced by the absorption of carbon monoxide are immediately indicated by a change in the level of the liquid in the U tube. The presence of as little as one part in ten thousand of carbon monoxide may thus be detected, and by the addition of a graduated scale the proportion of that gas may be estimated. Or, by substituting mercury for the coloured liquid in the tube, the apparatus may be so arranged that, when a poisonous quantity of carbon monoxide is reached, the expansion of the mercury completes an electric circuit and rings a bell.

USE OF PEAT FOR POWER PURPOSES.—A description is given by Mr. H. V. Pegg in the *Journal of Gas Lighting* (1912, CXIX, 395) of the results of using peat in a gas producer at Portadown. No preliminary drying of the peat was required, although the moisture varied from about eighteen to seventy per cent. according to the state of the weather. The gas produced was of good quality, but excessive spraying with water was necessary to remove the tar, while the plant required cleaning about once a week. The tar appears to be somewhat of a waste product owing to its persistent pyroligneous odour, which has resisted all attempts to remove.

The use of peat instead of coal reduced the bill for fuel by more than fifty per cent. The gas obtained from a peat containing 44·6 per cent. of carbon, 5·42 per cent. of hydrogen and 18·98 per cent. of moisture showed a calorific value of 144·0 B. Th. U., and had the following composition:—Carbon dioxide, 10·6; carbon monoxide, 21·0; hydrogen, 13·0; methane, 3·7; and total combustible matter, 37·7 per cent.

VARIATIONS OF NICOTINE IN THE TOBACCO PLANT.—The increasing use of tobacco extracts as insecticides has led to the cultivation of tobacco solely for this purpose. Since the insecticidal value of the preparations depends upon the proportion of nicotine they contain, they are usually bought and sold on the basis of the amount of that alkaloid present. It has, therefore, become a matter of practical importance to ascertain at what period of its growth the tobacco plant is richest in nicotine. In the experiments made by MM. Chuard and Mellet (*Comptes Rendus*, 1912, CLV, 293), with this object in view, it was found that there was a material loss of the alkaloid when the fresh plant was dried.

For estimating the proportions of nicotine in the growing plant, seeds were sown on April 25th, and analyses were made of different parts of the young plants at irregular intervals. On May 15th no nicotine could be detected, but a month later (June 16th) the leaves contained 0·35 per cent., and the roots 0·15 per cent. By August 9th the nicotine in the leaves had increased to 3·12 per cent., and in the roots to 0·69, while on September 18th, the date on which the leaves were gathered, the corresponding amounts were 4·79 per cent. in the leaves and 0·64 per cent. in the roots. The stalks contained about the same proportion of nicotine as the roots, while the amounts in the shoots varied from 0·49 to over one per cent.

Hence, the ordinary method of collection, in which only the leaves are selected, involves a considerable loss of nicotine, and it is suggested that a means might be devised for extracting the alkaloid from the waste portions of the plant, and to utilise the final residues for manure.

NATURAL GASES RICH IN HELIUM.—The gases emitted by some of the French mineral springs are particularly rich in helium, as is shown by the following analyses published by MM. Moureu and Lepape (*Comptes Rendus*, 1912, CLV, 197):—

Spring.	Helium in Gas Per cent.	Yield in litres per annum.	
		Natural Gas.	Helium.
Sautenay, Source Lithium ...	10·16	51,000	5,182
Sautenay, Source Carnot... ...	9·97	179,000	17,845
Maizières... ...	5·92	18,250	1,080
Bourbon Lancy ...	1·84	547,500	10,074
Néris	0·97	3,504,000	33,990
La Bourboule ...	0·01	30,484,800	3,048

XUM

Assuming that the helium present in these gases was originally derived from the disintegration of radioactive substances, it appears probable that it has not been produced immediately before its emission, but that it consists of gas which may have been formed some time previously from minerals in the vicinity and then dissolved by the water.

It is noted as a curious fact that these and other springs emitting gases rich in helium follow the course of a line extending through Moulins, Dijon and Vesoul.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

EARTHQUAKES AND GLACIERS.—A hitherto unsuspected relation between earthquakes and glaciers has been disclosed by recent work in the Alaskan region. This is fully set forth in Professional Paper No. 69 of the United States Geological Survey. During September, 1899, the region of Yakutat Bay, Alaska, was shaken by a series of severe earthquakes, which were attended by two notable results—great changes in the level of the land incidental to faulting, and remarkable subsequent changes in the adjacent glaciers. Both these remarkable effects entitle this earthquake to be regarded as a type, and as one of the great earthquakes of the world.

The changes of level are the greatest recorded in historical times. The maximum uplift, attested by raised beaches and other phenomena, amounts to over forty-seven feet. Similar measurements of vertical displacements are numerous along the fjords of the region; and not only faulting, but extensive tilting and warping of a complicated character have been demonstrated by these means. Barnacles attached to ledges high above present tide-marks, and amongst land shrubs; mussel shells still attached to rocks a score of feet above sea-level, afford clear evidence of very recent uplift.

Most of the Alaskan glaciers that have been studied shewed, at least up to 1905, distinct evidences of recent recession. Those of Yakutat Bay were found by Professor R. S. Tarr and L. Martin, the authors of the report, to be all in a state of recession when examined in the summer of 1905. In 1906 Professor Tarr returned to the region, and found a most astonishing change. In the intervening ten months many of the glaciers had advanced hundreds of feet, their smooth, moraine-covered surfaces were broken into a jagged sea of seracs and crevasses, and all were notably thickened.

This sudden, spasmodic advance is attributed to the effects of the earthquake of 1899. The Yakutat Bay glaciers are nourished by the normal accumulation of snow and ice over a vast region overhung by craggy mountain slopes on which great masses of snow are lodged in precarious situations. There is first-hand evidence that the great shaking of September, 1899, threw down enormous quantities of snow and ice into the gathering-grounds, and caused what must be regarded as an ice-flood, analogous to a river flood. The latter arrives in the lower reaches of the river in a few hours or days; the ice-flood causes a great advance at the foot of the glacier in a few years, the exact time being determined by the rate of flow and the length of the ice. Confirmation of this simple and beautiful explanation is found in the fact that the first glaciers to advance were the shortest. The longest of the Yakutat Bay glaciers have not yet responded to the earthquake shaking. Furthermore "the advance was alike in several respects in all the glaciers—it was abrupt and spasmodic, it caused profound transformation of the glacier surface, and it resulted in thickening at the termini—and all the glaciers quickly subsided and returned in a few months to a stagnant state after the effects of the rapid forward movement were spent."

The puzzling fluctuations of the termini of glaciers are usually ascribed to climatic variations; and this is probably the correct explanation in many cases. In earthquakes, however, we have provided an alternative cause of oscillation, undoubtedly operative in Alaska, and probably also in other glacier regions of the world.

PETROLOGY AT THE BRITISH ASSOCIATION.—Petrologists were in force at the Dundee meeting, and many interesting papers were read and discussed.

The seventh and final report of the committee on the composition and origin of the crystalline rocks of Anglesey summarizes a valuable piece of work. In all, forty-three complete rock analyses and twenty-five partial analyses have been made, which alone constitutes a notable addition to British petrography. In this report, a final series of analyses is given, mostly of metamorphic rocks; but one of a "variolitic pillowy diabase" has also been made, which is of interest in comparison with other spilitic lavas, and in view of the interest now taken in the "spilitic suite."

A most interesting discussion followed Dr. Flett's paper on "The Sequence of Volcanic Rocks in Scotland in relation to the Atlantic and Pacific Classification of Suess." The paper dealt mainly with four great groups of volcanic rocks: (1) The Carboniferous, typically "Atlantic" or alkaline in type, with olivine-basalts, trachytes, phonolites, mugearites, and later on teschenites, monchiquites and nepheline basalts; (2) The Old Red Sandstone, consisting mostly of andesites, and with typical "Pacific" or calcic characters; (3) The great Tertiary suite, unquestionably of Atlantic affinities, notwithstanding the Pacific types clustered around certain local centres; (4) The "spilitic suite," consisting of pillow-lavas and their associates, occurring in the Dalradian schists (Tayvallich), and in the Ordovician of the Southern Uplands (see "KNOWLEDGE," February, 1912, page 75, and April, 1912, page 152). The spilitic suite is considered by Dr. Flett to constitute a great division of igneous rocks equivalent in value to the Atlantic and Pacific divisions.

The discussion turned mainly on the validity of the Atlantic and Pacific classification, and on the status of the spilitic suite. The nomenclature especially of the former was attacked. Great confusion had been caused, it was alleged, by the use of the terms Atlantic and Pacific in a petrographic sense. They should be restored to their rightful owners, the tectonic geologists and geographers, and petrologists should revert to the terms "alkalic" and "calcic" for their two main divisions. Mr. A. Harker was a notable convert to Dr. Flett's view of the spilitic suite.

Mr. G. Barrow described a case of "magmatic differentiation intensified by dynamic action" in the older granite of Deeside. The granite permeates the crystalline gneisses over large areas in *lit-par-lit* fashion, forming minute sills, which vary from an inch to several feet in thickness. These have proceeded from dyke-like masses exposed in the hillsides. As the sills are traced towards their taper end, oligoclase and biotite steadily diminish in amount, their place being taken by alkaline felspar and muscovite. There is a concomitant increase in grain-size, the taper ends of the sills thus taking on a pegmatitic character. It is clear that under great pressure, the more acid, residual, liquid magma has been separated from, and driven farther into the gneisses, than the less acid, already crystallized material with which it was originally entangled.

Dr. W. Mackie described vesicular rhyolites with beautiful flow-banding, occurring round the Ord Hill of Rhynie, Aberdeenshire. These flows rest on an eroded surface of the diorites and gabbros of West Aberdeenshire—rocks which are considered to represent basic modifications of the younger Grampian granites. The rhyolites are faulted against Old Red Sandstone and are thought to be older than the oldest beds of this series. It seems to the present writer, however, that these rhyolites have a distinctive Old Red Sandstone facies, and may probably be correlated with similar rocks in the Lorne area.

The present writer described the alkaline igneous rocks of Ayrshire, which were recently dealt with in this column ("KNOWLEDGE," September 1912, page 342). An additional point of petrographic interest is the demonstration that the zeolitic mineral thomsonite may be of primary igneous origin, since it is found in the syenite of Howford Bridge, Mauchline, with exactly the same characters that give analcite so strong a claim to be considered as primary in this rock.

MICROSCOPY.

By F.R.M.S.

THE HARVEST MITE.—I was very pleased to see Mr. Marriage's photomicrograph of the Harvest Mite in the August number of "KNOWLEDGE," page 317, because it entirely agrees with some specimens sent to me by Dr. George, of Kirton Lindsey, in 1908. These specimens were sent to me alive and I made drawings of one, dorsal and ventral surface (see Figures 467 and 468), which was printed with Dr. George's article in *The Naturalist* for September of that year. What makes it still more interesting is that none of the previously-published figures I have seen agree so well with Mr. Marriage's photo-

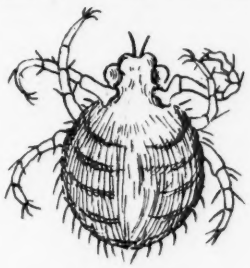


FIGURE 460.

FIGURE 461.

micrograph as my own. This may be accounted for by there being more than one larval form of the Acarina on the war path at the same time, which is always during the first active part of their existence, the larval stage immediately after leaving the egg. The larval forms of the Hydrachnids are always parasitic at this stage, but not afterwards.

Of course, there is no doubt about it being a larval form of some mite or other; but which mite is the question we have yet to settle. The larvae of *Trombidium holosericeum* and *Trombidium fuliginosum* are both well known. I have a number of each of them myself, but they do not at all agree with the one on page 317. Neither do we know of any one being bitten by either of them. A naturalist in Edinburgh bred some *T. holosericeum* larvae in confinement and placed the living larvae in his stocking but did not succeed in getting bitten. I tried the same experiment this year with *T. fuliginosum* with the same result—no bites. We also know by description and figures a number of larval forms of Trombidiums; but none agree with the larval form which we are sure causes the mischief that to some people is so distressing. It makes one wonder if the irritating little creature is a Trombidium at all. If some one could only succeed in keeping some alive long enough to reach the next stage it might help us very considerably in determining its proper place in the order Acarina. But at present we are quite in the dark as to its proper name, except we know it as *Trombidium autumnalis*.

The superfamily Trombidoidae is divided into six families—Caeciliidae, Cheyletidae, Erythraeidae, Tetranychidae, Rhyn-

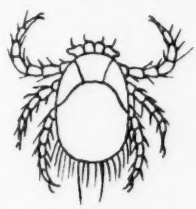


FIGURE 464.

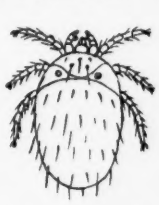


FIGURE 465.

FIGURE 466.

cholophidae and Trombididae, and these again into a large number of genera. The adult forms of the Harvest Mites are probably quite well known; it is only our ignorance as to which adult to ascribe the larval forms which does not allow us to give them their proper names. But when we do know, it is no doubt amongst one of the above six families we shall find them.

In the Autumn time the Harvest Mite is sure to turn up in person and in print. Some newspaper or other is sure to bring it forward, either seriously or humorously; even *Punch* had a joke out of them in 1907. But, however much has been printed, none have yet helped us to form a correct diagnosis of its true position in the Acarina. The bibliography of the Harvest Mite is very extensive, and covers a wide range of literature. Let us just glance at some of the references which are of easy access to the amateur naturalist.

The earliest account I have found is Baker's "Employment of the Microscope" (1753), page 343, Figure 1. Baker says:—"I have sometimes suspected this little creature might be a young sheep-tick from its figure and way of burying itself, but then it should be rather found where sheep feed, than in corn, and before sheep are suffered to come into those fields, and it is never got as I have heard in grass fields, unless bordering upon corn, but amongst wheat it never fails. If any one has a mind to make trial upon this insect, how it comes to be amongst corn only and yet live by sucking of blood, he may easily find abundance of them; for though they prefer the ladies, yet they are so voracious, that they will certainly lay hold of any man's legs that come in their way." Here is the opinion of Baker: he thinks it is a young sheep-tick, and his figures certainly help the conclusion. (Figure 460.)

Gilbert White in Letter XLIII mentions it, but does not attempt to call it anything but acarus.

Kirby and Spence also mention it, but help us no further with the name than *Leptus autumnalis*.

Kuchenmeister gives an account of this mite and a figure by

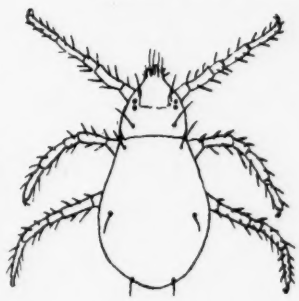


FIGURE 462.

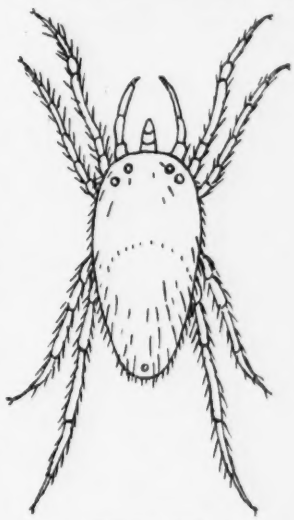


FIGURE 463.

Professor Leuckart. This figure is the nearest to Mr. Marriage's photomicrograph I have seen, and I should think is intended to represent the same creature, but he calls it by the same name as Kirby and Spence. (Figure 461.)

Banks, the American, writing on mites, says it is the larval form of a Trombidium. He does not mention any particular species but he gives a figure of the larvae of a Trombidium, which is quite different from the one in question. (Figure 462).

Murray, in "Economic Entomology," calls it *Tetranychus autumnalis*, gives a figure of the same, and takes it out of the family Trombididae; but the figure Murray gives is very different from Mr. Marriage's photograph. (Figure 464.)

The "Micrographic Dictionary," calls it *Trombidium autumnalis*, and gives a figure with eight legs, but says the young form with six legs is frequently met with. (Figure 463.)

"The Cambridge Natural History," Vol. IV., dismisses the the subject in the following few words:—"The Trombididae include most of the moderate-sized velvety red mites which are commonly known as Harvest-mites, and their larvae, the so-called Harvest-bugs, frequently attack man. *Trombidium holosericeum* is a well-known example." No Figure is given.

"Chambers' Encyclopedia" (1901), under Harvest Bug, says it is *Trombidium holosericeum* and gives a figure of the larva and adult. (Figures 465 and 466.)

It would be quite easy to give a large number of references, but those mentioned will show we are some way from the correct solution yet. We must keep on trying to breed the larval forms from adults in confinement of different species of mites until one is found that quite agrees with Mr. Marriage's figure and my own.

CHAS. D. SOAR.

DARK GROUND ILLUMINATION.—Of late years, microscopists have shown an increasing tendency to favour dark-ground illumination.

To this end, special condensers have been provided, but chiefly for high-power work. These have proved to be most efficient in depth of black ground in their defining powers, and also in their illuminating properties. Perhaps it may not be so well known that our ordinary condensers, the achromatics, and the Abbes, are fully as capable of good work as the new dark-ground condensers. They can be specially equipped in this direction for use with low and medium high power objectives. And the cost of this is inconsiderable.

The stand needs a substage fitted with a focusing rack and centring screws. The charm and the comfort of dark ground illumination is undeniable, and when you can add a beautiful effect and perfect definition to these advantages, you have an irresistible combination most desirable to possess.

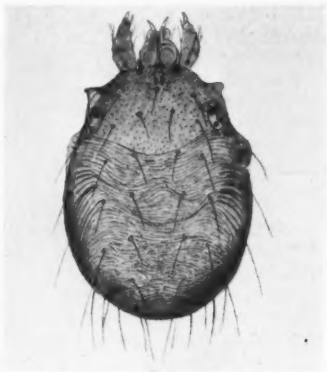
The materials necessary for this particular system are four or more watch-glasses, called "dead-flats" by the watch-makers. The thinner kinds should be chosen in order to provide room for coloured screen discs to rest in the same carrier. They should fit the carrier easily, yet without looseness. Six thin metal discs, varying in diameter from six-sixteenths of a inch to eleven-sixteenths of an inch, cut out with the lathe from sheaf-metal and bronzed, is the next requirement.

The nine-sixteenths of an inch disc may be taken to illustrate the process by which the working result is attained.

Spread any good cement, of the nature of seccotine, lightly over one surface of the metal disc, avoiding the actual edge. Place the disc on or about the centre of the glass disc, and put the latter, metal disc downwards, into the condenser carrier.

Remove the upper lens of the condenser, and rack it up as high as it will go under the stage of the microscope. Fit a two-inch power into the stand, and arrange the mirror so that the fullest light may pass through the axis of the sub-condenser.

Next, focus the two-inch objective upon the image of the disc, to be seen through the sub-condenser with a ring of white light around it. Then, with the centring screws, place the image of the disc and its surrounding ring of light in the centre of the field, and slowly close the iris diaphragm around the image of the disc. If the disc is not centred with the iris diaphragm, it must be delicately adjusted with the finger tip, or other agent, until the diaphragm sheaves close, and simultaneously shut out the light, all around the circumference of the disc.



From a drawing by C. D. Soar.

FIGURE 467.

The Harvest Mite × 145.

Upper side of the Body.

From a drawing by C. D. Soar.

FIGURE 468. The Harvest Mite × 145.

Under side.

When this is accurately done the result can be tested with a familiar slide, mounted for dark ground effects. First, always see, by observing the image of the disc through the objective and condenser, whether it is centred in the field. Then throw out the carrier and centre the fullest blaze of light you can get into the middle of the field by means of the mirror, concave or plane. Replace the carrier and put your slide upon the stage, and focus it with a two-inch objective, or other power, up to one inch.

Now gently lower the substage condenser upon its rack, and the light will increase, the definition will grow, until the full beauty of the subject of the slide is apparent. For this experiment, the iris diaphragm must be fully opened and the top lens of the sub-condenser removed.

Some condensers may present problems in the matter of focusing the image of the disc and its ring of light. Others, again, have their carriers so placed, that it is difficult to reach the disc underneath with the finger for adjustment, when the iris is being closed around the image of the disc. A little careful ingenuity will overcome all these difficulties. Always use a very low power to search for the image of the disc.

The proper disc for each objective must be found by experiment; try every diameter with each objective. The smaller the disc, the greater the light. Do not attempt to use any power higher than one inch with a divided condenser. The discussion of methods that are used with powers exceeding one inch, and with the complete condenser, may be resumed in another paper.

These methods differ considerably, and give the fullest satisfaction when objectives not exceeding one-eighth of an inch are used.

(REV.) R. FRANCIS JONES.

DIOPSIS.—Insects which fly are, as a rule, provided with two kinds of eyes, simple and compound, of which the former are of use to them when at rest or when walking about, whilst the latter give them distinct vision when in rapid flight. The simple eyes in the case of flies are generally three in number, and are set at different angles on an elevation upon the top of the head, but the compound eyes occupy a large space at the

sides of the head, and, especially in those species which fly rapidly, are frequently extended so as nearly to meet in front. In Diopsis, however, the position of the compound eyes is very peculiar, being placed at the ends of rigid stalks, or horns, extending from either side of the head and sometimes as wide apart as the entire length of the insect itself. These stalks also bear the antennae which are short and three-jointed, placed near to the eyes, the terminal joint bearing a long hair which probably acts like the whiskers of a cat by informing the bearer when there is danger of contact with objects in their vicinity.

Our illustration (Figure 469) shows the insect complete, magnified six diameters, and represents *Diopsis apicalis*, from Natal, and the head and eyes more highly magnified after having been prepared for microscopic examination by treatment which has rendered them translucent, and enables the nerves to be well seen which convey the sensations to the brain from the eyes and antennae.

The reason for this curious arrangement has not been clearly explained, as but little is yet known of the life history or habits of these insects; but the native who captured the specimen from which our drawing is made hazarded the opinion that as *Diopsis* is usually found on blades of grass growing near the river, it is enabled in this way to see what is going on beyond the leaf!

R. T. L.

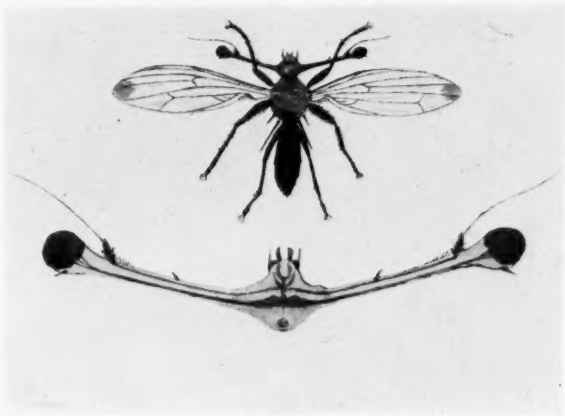


FIGURE 469.

Diopsis apicalis, from Natal. The complete insect × 6 diameters, and the head and eyes more highly magnified.

ORNITHOLOGY.

By WILFRED MARK WEBB, F.L.S.

THE BRENT VALLEY BIRD SANCTUARY—AN EXPERIMENT IN BIRD PROTECTION.—As mentioned in the column last month the writer, in his capacity as Secretary of the Selborne Society, gave an account of the work which had been carried out during the past few years in the Brent Valley Bird Sanctuary to the Conference of Delegates of the Corresponding Societies of the British Association at Dundee. As the paper may be of interest to our ornithological readers, it is here printed:—

"The difficulties of administering the Wild Birds' Protection Act are well known; but it is possible for individuals and societies, with a little trouble, to do something towards preserving birds, and it is an experiment in this direction which I am going to describe.

"Some eight or nine years ago it was suggested at a Committee Meeting of the Brent Valley Branch of the Selborne Society that some steps might be taken to protect the Nightingales, which were known to nest in a wood of about nineteen acres lying between Ealing and Harrow, which comes within the boundary of the London postal district. A small sub-committee of three members, of whom I happened to be one, was appointed to make arrangements, if possible, for the wood to be watched in the nesting season.

"As a result, it became part of the duties of a farm-hand to attend to warn off bird-catchers and bird's-nesting boys. After a year, however, the Committee took over the wood, employed a watcher of their own, and kept up the hedges with their own hands. But though success was attained in other directions, the nightingales were not heard for several seasons; in fact, not until the appointment of the present keeper, who is engaged all the year round, and takes a particular interest in his work.

"I may say now that the wood is composed of oak trees with coppice below, chiefly consisting of hazels, though there are many other trees and shrubs represented, and these have grown to a considerable size in places that have not been regularly cut every so-many years.

"Among the common birds that build as a rule are the Song Thrush, Missel Thrush, Blackbird and Hedge Sparrow; but there are often special points of interest concerning even them with regard, for instance, to the material of the nest, its position, and variations of the eggs.

"As a rule, too, from the beginning there have been each year a Chiffchaff's nest and several Willow Warblers'. The Garden Warbler and Whitethroat always breed and so does the Lesser Whitethroat, while the Turtle Dove builds every year. We have only once followed the development of the young cuckoo, though the eggs were found in the wood before it was protected. We have had on one occasion a wild duck's nest; but the parent birds were most probably shot outside the confines of the wood.

"The Long-Tailed Tit at one time was common and it is almost the only bird that has not increased in numbers. The Wren is numerous and builds in the open or under cover in empty tins or old kettles which may or may not have been put up for the purpose. The Robin is another bird which has the habit of making its nest sometimes in natural and sometimes in artificial surroundings.

"It is noticeable, however, that with the exception of an occasional pair of Blue Tits, one of which nested in a hollow branch, none of the birds which commonly build in holes, except the two already-mentioned, were found to nest. This, no doubt, was owing to the fact that the oak trees in the wood are young and sound.

"At the beginning of one season, however, my boy took it into his head to make some rough nesting boxes with large openings and, that summer, nests were recorded of the Flycatcher, the Great Tit, and the Tree Sparrow. Then other boxes were made with various-sized openings, and of more careful construction. These succeeded marvellously well. Blue Tits and Coal Tits built, the Tree Sparrows and Great Tits increased in number and the Wrens and Robins made use of the boxes as well as of the tins and kettles. The Nuthatch made its appearance and has been a resident in the wood ever since. Experiments were also made in the way of open boxes for Flycatchers, while trays for Blackbirds and Thrushes, which were fastened to the trees, found favour with some birds, in spite of the almost unlimited possibilities for their building in the undergrowth. Some of the visitors, whom we admitted sparingly in those days, asked us to make nesting boxes for them. The reputation of these dwellings spread, and as we were only too anxious to retain the services of our custodian, we were glad to be able to keep him busy in the winter, and the profits on the boxes went towards the expenses of the wood. It soon became evident that improvements could be made in the nesting boxes. For gardens also it might be advisable to have something a little less artificial looking. The only boxes on the market made from natural logs, with which we were acquainted, were those designed by Baron von Berlepsch.

"To these we found several objections:—

"(1) First of all they were manufactured in Germany.

"(2) The idea of making them harmonize with their surroundings was not carried through, because there was a piece of ordinary board screwed on to the top of the log.

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"(3) The lid could not be lifted off at any time for the contents to be examined, and considerable trouble had to be spent in unscrewing it in order to clean out the boxes at the end of the season.

"(4) The inside, which was cut out very carefully to imitate the hole bored by a Woodpecker, did not provide much room in the smaller-sized boxes for large broods, and all the trouble was thrown away in the case of all those which were fastened low down on the trees for the smaller birds. I therefore spent some amount of time and trouble, with the help of a member who has a joinery works, in producing a kind of box suited to our requirements, and these have been very successful. We made very rigorous tests last year with which we were quite satisfied.

"We find, also, that the opening of the box at the top (instead of at the front) does not disturb the birds if they happen to be sitting. A great deal more pleasure is, therefore, given to those who put up the boxes. The eggs and young can also be seen more easily, and quite useful nature study observations can be made, in which case even the commonest birds are useful.

"We have not forgotten that birds like the Woodpecker and the Wryneck make no nest and if their eggs are to be kept together for hatching a flat-bottomed box is useless. The bottoms of all the boxes are slightly curved, but special cup-shaped bases are put into those which are fastened high in the trees. We make specially large openings for Robins and restrict the size where only birds useful to the gardener are to be encouraged. It is useful to bear in mind that the Common Sparrow and Starling seldom build low down.

"I might call attention to the fact that a small series of boxes is on view in the Zoölogical collection arranged at this meeting of the British Association by Section D (Zoölogy).

"In addition to the birds that nest, we have a number that always seem to be present, but whose eggs we have not found. The list includes three species of Woodpecker, and the Brown Owl, which up to the present has refused all the nesting sites put up for its benefit. The Barn Owl is often to be seen, as is the Golden-Crested Wren. The Nightjar has been present during three seasons, the Kingfisher is a common visitor, and Jays and Magpies occasionally appear.

"Snipe sometimes frequent the outskirts of the wood and, on one occasion, I found a dead Woodcock within its boundary. This bird my wife had apparently seen alive a few days previously. Recent records include the breeding of the Goldfinch, Redpoll, Marsh Tit and the Wryneck.

"It will be noted, however, that very few of these birds are really rare; but it is the object of the Committee to protect those which occur near London. In the Brent Valley, there are few crops grown that the birds are likely to damage; but in other localities it might have to be borne in mind, when doing similar work, that certain species should not be unduly encouraged or indeed given protection.

"It is practically impossible to describe all the pleasure that can be obtained from such a reserve. It is a source of interest all the year round, and the mammals, reptiles, insects, and other creatures should be taken into consideration. The mice are somewhat destructive to eggs, but the way in which they utilise old birds' nests is worthy of attention. The fungi may be mentioned and a bird reserve also becomes a sanctuary for flowering plants. Steps will be taken to form committees in other parts of the country, and I should be very pleased indeed to give any advice that I can to those who are thinking of protecting any definite areas in the way which has been outlined."

"BRITISH BIRDS."—The October number of this Magazine contains, as usual, many interesting notes. Miss Turner contributes an article and photographs on the Bearded Tit, while the Rev. F. C. R. Jourdain discusses the known cases of hybrids between Black Game and the Pheasant. A clutch of white eggs of the Ringed Plover is recorded for Blakeney Point in Norfolk, and we have accounts of the attempted breeding of the Grey Wagtail in Surrey, as well as the probable nesting of the Pied Fly-catcher in Moray. Another matter of interest is the case of a Stock Dove laying again, as the Common Pigeon sometimes does, while its young were still in the nest.

PHOTOGRAPHY.

By EDGAR SENIOR.

EXPOSURE TABLE FOR NOVEMBER.—The calculations are made with the actinograph for plates of speed 200 H. and D., the subject a near one, and the lens aperture F.16.

Day of the Month.	Condition of the Light.	Time of Day.	
		11 a.m. to 1 p.m.	9 a.m. and 3 p.m.
Nov. 1st	Bright	·22 sec.	·3 sec.
,, ,,	Dull	·44 ,,	·6 ,,
Nov. 15th	Bright	·25 sec.	·46 sec.
,, ,,	Dull	·5 ,,	·93 ,,
Nov. 30th	Bright	·3 sec.	·75 sec.
,, ,,	Dull	·6 ,,	1·5 ,,

Remarks.—If the subject be a general open landscape, take half the exposures given here.

PHOTO-MICROGRAPHY OF OPAQUE OBJECTS.—Of late, considerable attention has been given to studying the microscopical structure of metals and alloys (metallography), and in this work photography plays a very important part. The specimens, which may be either fractured surfaces or polished ones etched with some material suitable to show the desired structure, may, "if small," be held in position on a glass slip by means of plasticine. In any case, the objects, being opaque, require to be illuminated by means of reflected light. When using low powers, diffused daylight is probably the best to employ, as an even illumination without deep shadows should generally be aimed at. In this case a vertical camera is a great advantage, as good lighting can be more readily obtained by its use. When employing daylight the camera should be placed near a fair-sized window, in such a position that the light falls upon the object from above as well as from the side. With a little care and attention to details it will be found fairly easy to obtain good results in this way. This method, however, is only suitable for very low magnifications, and even then unless the light is very good the exposure is unduly prolonged.

For many objects a condenser may be employed but care must be taken to avoid too much glare. When using artificial light such as an oil lamp, the bulls-eye condenser will be found useful, and this, when used in conjunction with a parabolic reflector will be found to illuminate opaque objects beautifully. Methods of this kind, however, can only be made use of with low powers such as twenty-four millimetre or sixteen millimetre objectives, as with lenses of a shorter focus than this, the working distance is too close for the light to reach the object. In this case some form of vertical illuminator, an appliance for passing the light through the objective becomes necessary. In its simplest form this consists of a thin circular disc of glass contained in a short mount which is attached to the lower end of microscope and into which the objective is screwed. A beam of light directed upon an aperture in the side of the mount by means of a bulls-eye, falls upon the reflector, and is projected downwards through the objective, and thus illuminates the object. This illuminator being transparent allows the light reflected from the specimen to pass through it, and reach the eyepiece, by which the image is viewed, in the ordinary manner. Care has to be taken in the adjustments of the apparatus, in order to avoid any veil or mistiness being imparted to the image under observation.

Instead of the disc of glass a small prism may be used, when a beam of light directed upon the opening in the side of the mount falls upon the prism, and becomes totally reflected from the hypotenuse surface downwards through the half of objective which it covers, and reaching the object brilliantly illuminates it. Thus the image seen through the eyepiece is entirely produced by the uncovered half of objective. For either method of lighting, the object should be uncovered or in optical contact with the cover glass, and objectives of higher

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power than sixteen millimetres must be specially corrected for uncovered objects. When oil immersion lenses are employed the specimens may then be covered. In order to reduce reflections upon the lens surfaces as much as possible, the objectives should be mounted in a manner which allows the back lens to be as close as possible to the prism. With this form of illuminator there are usually supplied thin metal diaphragms which slide into slits cut in the body tube; their use is to cut off reflections which give rise to a hazy appearance in the image, and, being adjustable from right to left. the position in which the image is seen at its best must be found by experiment. It is also advisable to reduce the image of the source of light "by means of an iris diaphragm," so that it is not larger than the field of view of the objective. As a deal of care is necessary in the adjustment of the light in order to get the best effect, special microscopes have been designed for use in metallography. These instruments have an adjustment for raising and lowering the stage, and as a fine adjustment is provided as well, the whole of the focusing is performed by this means, thus avoiding any shifting of the light by movement of the tube of the microscope. Excellent results can, however, be got with an ordinary microscope, although more time is occupied in obtaining them, and in the illustration (Figure 470) we have an example showing a photomicrograph of the etched surface of some cast steel, in which an ordinary microscope was employed, and light from a paraffin oil lamp the source of illumination.

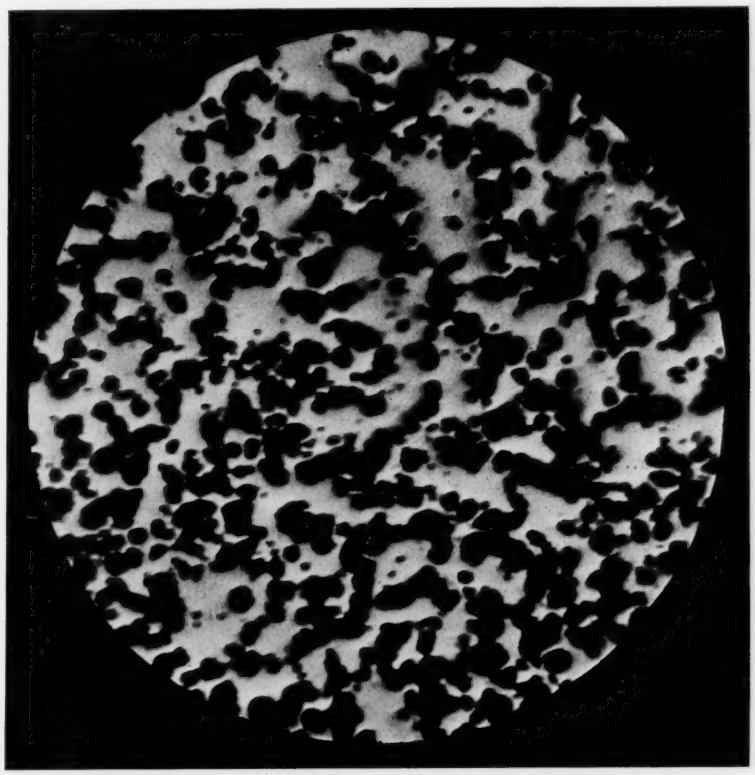

FIGURE 470.

Cast steel × 220 diameters. Photographed with an eight millimetre objective and Zeiss vertical illuminator, together with a four projection ocular.

PHYSICS.

By ALFRED C. G. EGERTON, B.Sc.

RESONANCE SPECTRA.—Professor Wood has continued his researches during the last summer on the resonance spectra of iodine vapour when it is excited by waves of light of different wave-length. His former work had showed that a very small difference in the wave-length of the exciting light caused a very great difference in the iodine spectrum; the latter differs when it is excited by the green line of the Cooper Hewitt mercury lamp made of glass from the spectrum obtained when excited by the same line from a similar lamp made of quartz but working at a higher temperature. It appeared that the exciting line might be broad enough to act upon more than one absorption line. The spectrum of the light absorbed by iodine vapour is very complicated. Professor Wood has estimated the number of absorption lines at fifty thousand; seven distinct lines were visible within the green mercury line, the wave-lengths varying from 5460·966 to 5460·579. To be able to make these measurements of wave-length with such remarkable accuracy, Professor Wood has constructed a very powerful spectrograph and as befits his well-known ingenuity, he has made it in a somewhat novel manner. The large plane grating was mounted on a cast iron pillar outside the laboratory, the slit and photographic plate-holder was fixed on another pier just inside; these piers consisted of jointed water mains, while a bevel gear taken from an old hand-drill served to rotate the grating. The lens was one of forty feet focus and threw the spectrum on to the plate. Rectangular tubes made of wood connected the different parts of the apparatus, but they were not rigidly joined up so as to prevent errors arising from vibrations set up by wind or other source. This spectrograph, though constructed in such a simple manner, is probably the most powerful in the world. One interesting result obtained with this instrument is that there appear to be many coincident lines in the absorption spectrum of iodine and of bromine its kin amongst the elements. This would suggest that possibly there exist in the two elements identical systems of electrons, which give rise to similar frequences in the two molecules.

ABSORPTION SPECTRA.—Much work has been done on the absorption spectra of organic compounds, similarity in the position of the maximum of absorption being taken as a clue to similarity of structure of the molecule. The origin of the colour of an organic substance is supposed to be due to certain groups within the molecule called chromophoric groups; the simpler substances containing the chromophoric group usually have absorption bands in the ultra-violet or violet, so that they are yellow in colour and as the molecule gets heavier, with the addition of other groups the positions of the absorption bands shift towards the red end of the spectrum, consequently the colour of the compound becomes redder and then purple and finally blue. The mutual attractions between the groups within the molecule cause alterations in the vibration of the chromophoric group which is responsible for the absorption of the light, and the colours do not usually quite go through the series of colours that should theoretically be yielded by the formation of substances

containing the chromophoric group and of gradually increasing molecular weight. The continual transformation of one form of a substance into another molecular form of the same substance, or tautomerism as it is called, is supposed by some to give rise to the colour of many organic substances. However, most of this work has been of a qualitative nature; the results have been recorded on photographic plates, and it is not possible from a variety of causes to judge accurately the intensity of the absorption from examination of the plates. Quantitative measurements have lately been made by means of different spectrophotometers. In one such instrument the upper and lower halves of the slit are illuminated by beams of light polarised at right angles to one another, and the relation of the intensities of the two beams is given by the equation, $I/I_0 = \tan^2\theta$, where θ is the angle through which the analysing nicol is turned.

By means of an apparatus such as this, the extinction coëfficients can be found for various wave-lengths of the light throughout the spectrum, and the curve of absorption can be accurately plotted. Houston and others have made investigations on the salts of many inorganic coloured substances, and have tested the influence of different substances in combination with the coloured metal molecules. Merton has tried the difference in the absorption spectra of pure uranous and uranyl salts in various solvents, and has found that solutions in different solvents give quite different absorption spectra; but the apparent gradual shift observed when one acid radicle is replaced by another in the same solvent can be explained by the superposition of the absorption curves of the two compounds. It appears that the solution of a substance in a solvent is attended by considerable influence of the solvent on the dissolved substance, such that the molecular vibrations of the latter are disturbed by the presence of the molecules of the former.

THE COUNTING OF α PARTICLES.—Professor Rutherford has improved his apparatus for counting the α particles from radioactive substances. The radioactive material was placed in an exhausted tube behind a mica disc with a hole in it, placed at the end of a testing vessel within which is an electrode, which is connected to an electrometer. A definite fraction of the α particles pass through the hole and ionise the air in the vessel, which is at low pressure; this ionisation magnifies their effect enormously and a throw of the electrometer needle results. The experiments have been carried out lately with improved apparatus—special devices for preventing the scattering of α particles on entering the vessel for counting the number of throws of the electrometer needle (even one thousand per minute can now be counted), each corresponding to the entrance of one α particle. It is now possible to detect the electrical effect of one α particle when it traverses a gas at such a low pressure that its range is only reduced by $\frac{1}{20}$ mm.! This is a remarkable experimental achievement, when the small mass of the α particle (which is the same as a positively charged helium atom) is considered!

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

A WHITE PORPOISE.—In Notes No. XXXIII from the Gatty Marine Laboratory, St. Andrews, Professor W. C. McIntosh reports the capture of a white porpoise in St. Andrews Bay. It was a young female thirty-four inches long, of a dull yellowish-white all over like a Beluga. A faint longitudinal band occurred along the upper lateral region on each side, and there was a somewhat crescentic dark patch from in front of the eye to the angle of the mouth. The eyes had the normal pigment. It may be said that this interesting white form retained traces of embryonic hues.

LONGEVITY OF BIRDS.—Anecdotal statements as to the longevity of birds are as common as precise records are rare. L. Petit, Senior, communicated recently to the Zoölogical Society of France, a number of records that he was prepared to vouch for. We quote a few instances—a sparrow of eight, a black-headed gull of ten, a blackbird of eleven, a small cardinal of fourteen, and an Amazon parrakeet of twenty-five years.

MARSUPIAL AMPHIBIANS.—In describing a new species of *Nototrema* from Brazil, L. G. Andersson discusses the origin of the dorsal pouch in which the eggs develop. In the female examined there was no trace of an opening to the exterior, though a large empty pouch extended as far as the head. It seems likely that the opening to the pouch closes up after the young have escaped. Weinland, who first described the pouch of Nototrema, regarded it as due to an intucking of skin, the upper leaf of the infolded skin coalescing with the dorsal skin. Another view, supported by Brandes and Schoenichen, that the pouch is formed from the dorsal coalescence of two longitudinal lateral folds, is based on the study of *Nototrema pygmaeum*. In this case it is supposed that the median suture opens along its whole length when the young escape; that the pouch completely disappears, and that it is formed anew next season. But Andersson's new species *Nototrema fulvorufa*, had a large empty closed pouch. The author suggests that the pouch in *Nototrema pygmaeum* may correspond to a sort of porch or vestibule to the real pouch of his specimen. "The outer part of the pouch, the vestibulum, originates from two low lateral folds, which grow towards each other, and disappear again when the young ones leave the pouch."

GLACIER-FLEAS.—As a fine example of the exuberance of life in a most unpropitious place, we may refer to J. Vallot's account of the multitudes of "glacier-fleas" (*Desoria nivalis*) which he observed on the *mer de glace* at Chamonix between "*l'Angle*" and "*les Moulins*" (see *Comptes Rendus* CLV, 1912, pages 184–185). These "glacier-fleas," discovered by Desor, are minute and primitive wingless insects, belonging to the family of Podurids; but they are so rare that Vallot had never before seen them in his twenty-five years' experience of Mont Blanc. Yet there they were covering the small pools of water on the melting ice, ten of them on a square centimetre! They occurred over a stretch of glacier twenty metres broad by two thousand metres long, and there must have been forty millions of them. This illustrates the extraordinarily rapid multiplication of a very rare type, and the quality of insurgence which is so characteristic of life.

SELF-EVISCERATION IN A STARFISH.—The unpleasant word "self-evisceration," somewhat suggestive of Hari-kari, denotes an interesting propensity or infirmity which is very familiar in sea-cucumbers or Holothuroids. Mr. Nathaniel Colgan has observed a case of it in the crimson starfish *Cribella oculata* or *Henricia sanguinolenta*. The process began by the appearance of a small lump of caeca on the upper surface and near the tip of one of the arms. The extrusion went on until one pair of caeca was fully exposed. It occurs "not by a catastrophic rupture, but by a long-continued series of muscular efforts, all tending towards the same end." In two cases there was extrusion of gonads as well as caeca. Further experiments are necessary before it can be maintained that the "self-evisceration" is adaptive, for the specimens were kept in unnatural conditions. "Exposed as they were to strong light for considerable periods while barely covered with water, which from time to time became more or less foul as compared with their native element, the animals must necessarily have grown sickly, so that the long-drawn-out muscular efforts which finally effected the extrusion of the viscera may have been merely symptoms of the approaching death of the organism."

A ZOÖLOGICAL PUZZLE.—In Ordovician, Silurian, and Devonian strata there are curious coral-like masses, usually hemispherical or cake-like, which are known as Stromatoporoids. They were monographed by the late Professor Alleyne Nicholson, who regarded them as Hydrozoa. There has always been great doubt, however, as to their real position, chiefly because of the difficulty of deciphering their structure.

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Within the last eighty-six years they have been regarded as as Foraminifera, calcareous, horny, Monaxonellid, and Hexactinellid Sponges, Hydroida, Hydrocorallinae, Alcyonarians, Anthozoön corals, Polyzoa, Cephalopoda, and vegetables! Mr. Kirkpatrick, of the British Museum, has now come to the conclusion that they are Foraminifera. A vertical section shows apparently a meshwork of regular or irregular radial and concentric calcareous strands, which are really the edges of walls of Foraminiferal chambers. It may be noted as an indication of the difficulty of the subject that Mr. Kirkpatrick, who calls the Stromatoporoids Foraminifera in September, called them Sponges in August. He returns to an old zoölogical puzzle, that of *Eozoön canadense*, a reputed fossil from Lower Laurentian serpentines. Most zoölogists have of late agreed to surrender *Eozoön* to the petrologists; but Kirkpatrick revives Carpenter's conclusion that it represents a genuine organism. He regards it as belonging to the Foraminifera, nearly related to Labechia and Beatricea.

SOLAR DISTURBANCES DURING SEPTEMBER, 1912.

By FRANK C. DENNETT.

SEPTEMBER contrasted strongly against August in the amount of solar activity observed. On five days only—1st to 3rd, 29th and 30th,—was the disc recorded as free from disturbance, and on four others—4th, 5th, 22nd and 23rd—only faculae were noted. On the remaining twenty-one days spots were visible. The longitude of the central meridian at noon on September 1st, was 174° 59′.

No. 15.—A group of pores first seen on September the 6th, amid bright faculae just round the eastern limb. There was much variation in the grouping of the pores from day to day. The diagram figures it upon the 9th. On the 12th only a little gray pore marked the place of the leader. Its greatest length was 67,000 miles.

No. 16.—A pair of spots near the western limb, in a group of faculae only seen upon the 8th.

No. 17.—A considerable faculic area was visible a little way on to the disc from the east limb on September the 10th. On the 12th or 13th a small black spotlet appeared in this area with two pores just ahead of it. On the 14th it was a group 45,000 miles in length, and later increased to 60,000 miles. The spots attained their greater diameter on the 18th, when the region directly north-west of the largest middle umbra appeared of a light violet colour as seen with an unsilvered glass Newtonian reflector. It was last seen close to the western limb on the 21st.

No. 18.—A group of spotlets and pores broke out amid faculae nearing the western limb on the 14th, and was last seen next day.

No. 19.—A tiny pore on September 24th directly in front of a faculic disturbance close to the east limb. On the 25th, there was a little triangle of pores with a tiny point behind it. On the 26th the leader and the trailer had both enlarged, the former containing three umbrae. It had decreased on the 27th, and when last seen on the 28th only a tiny pore remained.

On September 22nd, Mr. Booth kept in view a tiny pore, approaching the central meridian, but distant about 13°, with a twelve-inch unsilvered glass Newtonian, using powers varying between eighty and four hundred diameters. He estimated that from four to six of the minute granulations which go to make up the photosphere would have covered up the pore. His drawings are reproduced in Figure 471. A, at 9 a.m.; B, 10 to 10.30 a.m.; C, D, and E show dull fluctuating lanes amid the granulation; F, a bright lip on the western or preceding side of the pore; G, a dull lane containing veiled pores; H, a stationary veiled patch from 1 until 2.15 p.m.; and I shows the pore, at 4.20 p.m., set within curves of minute points joined by thin dark lines.

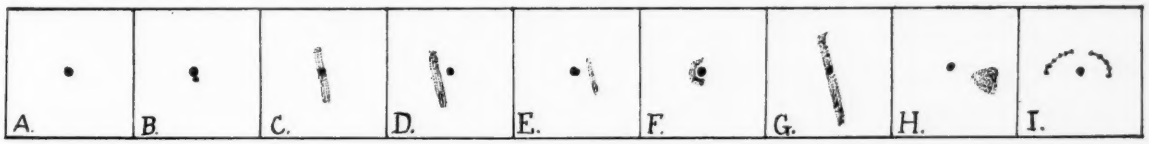
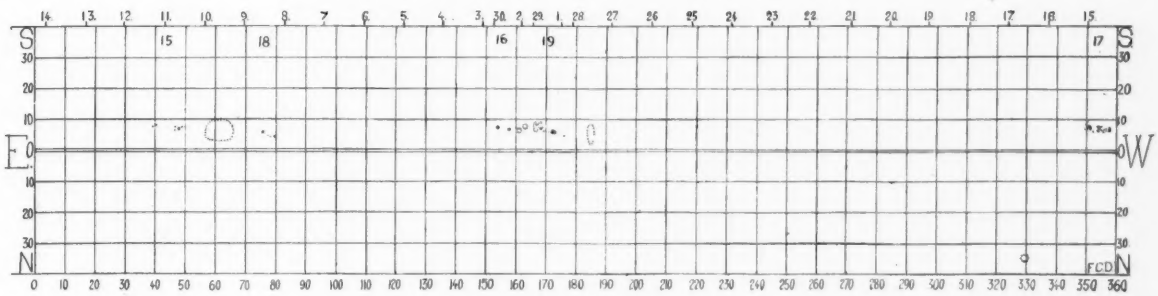


FIGURE 471.

Faculic areas were recorded around longitude 62°, latitude 8° S. from September the 4th until the 7th; at 329°, 35° N., on the 21st, at 185°, 5° S. on the 23rd and 24th; and between the sites of groups numbered 16 and 19, on the 24th and 25th.

The chart is constructed from the joint observations of Messrs. J. McHarg, A. A. Buss, E. E. Peacock, C. Frooms, D. Booth, and the writer.

DAY OF SEPTEMBER. 1912.



C

REVIEWS.

BIOCHEMISTRY.

Oxidations and Reductions in the Animal Body.—By H. D. DAKIN, D.Sc., F.I.C. 135 pages. 9¾-ins. × 6-ins.

(Longmans, Green & Co. Price 4s. net.)

This volume forms one of the excellent series of monographs on biochemistry now being issued under the general editorship of Drs. R. H. A. Plimmer and F. G. Hopkins. Biochemistry, though quite a young science, is a rapidly-growing one, and this series, therefore, supplies a very real need. A series of short monographs, moreover, has the advantage over a large text-book covering the whole ground that it may more easily be kept up-to-date, by revising volumes when necessary.

The present book gives a full account of the work that has already been done on oxidations and reductions in the animal body. As to the latter, not much seems to be known. Everyone is aware, however, that many compounds (*e.g.*, carbohydrates) containing carbon and hydrogen are oxidised in the animal body to carbon-dioxide and water, thereby producing the heat necessary to life; but it is in very few cases that these simple compounds are produced immediately from the complex ones; more generally they result from long series of katabolic changes, and the study of the intermediate compounds produced is not only of interest and importance for the chemist, but also for the physician.

The course of oxidation in the animal body does not as a rule follow that obtained *in vitro* by the use of the ordinary laboratory oxidising agents, but it can generally be obtained *in vitro* by the use of hydrogen peroxide. It seems likely, therefore, that oxidations in the body are produced by means of unstable superoxides. Fatty acids undergo oxidation only in the β position, a truly remarkable change, which can only be produced *in vitro* by the aid of hydrogen peroxide. Knoop studied the fate in the body of fatty acids in which a resistant radical had been introduced, as otherwise complete oxidation generally results. He found that whilst benzoic and phenylacetic acids were unoxidised, phenylpropionic and phenylvaleric acids were converted to benzoic acid and phenylbutyric acid to phenylacetic acid (of course, the products obtained from the urine were combined with urea), and was thus led to the above generalisation. In support of this theory it may also be mentioned that only those fatty acids yield acetoacetic acid when perfused through a surviving liver which contain an even number of carbon atoms, showing that the acetoacetic acid results by continued oxidation in the β position.

The contents of the book have been admirably arranged, and its value is enhanced by the inclusion of a very complete bibliography. The only point we are inclined to criticise is that the diagram on page 66, showing the conversion of phenylalanine into acetoacetic acid in the body, is apt to give the impression that phenylacetic acid when perfused through a surviving liver as an intermediate product, which is not the case, since, as Dr. Dakin points out, phenylacetic acid, if administered, is excreted without oxidation as phenaceturic acid.

H. S. REDGROVE.

BIOLOGY.

The Mechanistic Conception of Life. Biological Essays.—By JACQUES LOEB, M.D., Ph.D., Sc.D. 232 pages. 58 figures. 8¾-in. × 5¾-in.

(The Cambridge University Press. Price 6/- net.)

This volume contains ten essays (reprinted from various sources) dealing for the most part with experimental biology. Interspersed, however, are occasional metaphysical speculations and criticisms of other metaphysical speculations; and the main object of the writer seems to be to illustrate and enforce the theory laid down in the essay which gives the title to the volume. The mechanistic conception of life which the author advances is that the sum of all life phenomena can be unequivocally explained in physico-chemical terms. But a complete scientific account of life must take account of all the relations involved therein, and, as Professor Lloyd Morgan has pointed out, there is absolutely no justification for excluding the conscious relation. And, however far it may be possible to explain all biological phenomena in terms of matter and motion (or inertia and energy)—and certainly physical science is justified in making the attempt—Huxley's objection still holds that we know matter and motion only as forms of consciousness, and hence, no explanation of consciousness is logically possible in terms of matter and motion. As a specimen of Dr. Loeb's metaphysics the following may be quoted—"Nobody doubts that the durable chemical elements are only the product of blind forces"—but does any metaphysician believe it?

The speculative portions of Dr. Loeb's essays (with their hypostatising of force, and confusion between a scientific account of phenomena aiming at co-ordination of relations and a metaphysical explanation of the source of phenomena) need not be taken very seriously. It is better to ignore all such speculations and pay attention only to the purely scientific portions of the book. These will be found full of interest and value by scientific men who are not sufficiently specialists in biology to wish to consult the original memoirs of Dr. Loeb's and other investigators' experiments. Dr. Loeb's experiments in artificial parthenogenesis are particularly important, and throw much light on the physico-chemical aspect of fertilization. It appears that, in the case of the eggs of the sea-urchin, and some other cases, two processes are necessary for fertilization. First, the cortex of the egg must be cytolized, to allow the formation of what is termed a fertilization membrane. This can be artificially brought about by means of butyric acid. The spermatozoon probably effects it by means of a lysin. The second process seems to be of a corrective nature. It can be brought about artificially either by placing the egg in hypertonic sea-water containing oxygen, or in isotonic sea-water free from oxygen (or containing a trace of potassium cyanide, which prevents oxidation), after which it is transferred to ordinary sea-water.

There are also interesting accounts of various tropisms, the heliotropism of the aphid being particularly remarkable. Indeed, in this respect the aphid behaves just like a machine, and Dr. Loeb's explanation, in terms of the action of light, through the optic nerve, upon one of a pair of symmetrical muscles, is probably correct. But it is well to remember that all the actions even of an aphid are not of the nature of tropisms.

H. S. REDGROVE.

Aristotle's Researches in Natural Science.—By THOMAS EAST LONES, M.A., LL.D. 274 pages. 10 illustrations. 8¾-in. × 5¾-in.

(West, Newman & Co. Price, 6/- net.)

The writer of this book has undertaken a useful and an interesting task. It is no other than to clear a road for the student of Aristotelian science by setting forth, in the order and style of a modern text-book, the main facts of Aristotle's scientific knowledge and teaching. While in some of Aristotle's philosophical treatises his style is in the highest degree polished and clear, this is not always the case in his writings, and it is certainly not so, for instance, in his History of Animals. This, and some of the other books, are full of repetitions and seem strangely disordered: so much so that critics sometimes speak of them as having come down to us in the form of mere lecture notes, never set in order for publication. Accordingly, with all the help that translations can give us, it is not easy to find out what Aristotle precisely said, or what he probably knew, regarding any particular thing; still more is it difficult to get

a general view of the range of his scientific knowledge. Such an epitome as Dr. Lones now gives us is a great help to the student, and I think it will be welcomed by all naturalists and physicists who care for the historic aspect of their science. In such an epitome one loses much; one misses Aristotle's homely style of narrative and all the archaic terms of his phraseology, which even a translation does not let us wholly lose. There is a certain charm in the discursiveness of his style, in which one seems to trace how his mind caught up point after point, and where every here and there some great and original thought looms out amid the simpler narrative. But the epitome serves a good and even indispensable purpose of its own, and in this case it seems to have been made with skill and learning, and with loving sympathy for the work of the philosopher.

In an introductory chapter the writer gives us a brief and pleasant account of Aristotle's life, of his various writings and of the history of Aristotelianism. He reminds us, for instance, that the phrase "there is nothing new under the sun" was an old saying in Aristotle's day, and was a favourite of Aristotle's own. He sketches some of the many ideas, or some of the many words, that come to us direct from Aristotle; he shows us, for instance, that in such familiar words as form and habit, faculty and energy, essence and quintessence, we are using Aristotle's language; that diptera and coleoptera and selachia and cetacea are Aristotle's own words; that the physicist, the naturalist and the metaphysician are, *ipso nomine*, Aristotelians.

The book proceeds in the next place to give us an account of Aristotle's physical writings, such as are contained in his work on Meteorology and in his tract on the Heavens; and then, in greater part, it consists of an orderly account of Aristotle's Natural History, as gleaned from the various biological treatises. In the beginning of this latter portion of the book we find an account of Aristotle's discussion concerning the relation between animals, plants, and things inanimate, the various forms or grades of the "Vital principle": in short, the question of the passage from lifeless to living matter, which is to-day as open to discussion as ever, and can scarcely be discussed at all without reference to Aristotle's own terms and arguments. From the manner of composition of the elements, fire, water, earth and air, we are led on to the tissues and organs of the body, the description of which leads off into many interesting bye-ways of physiology and anatomy. And lastly, after brief chapters on animal locomotion and on generation and development, the book ends with an account of Aristotle's classification of animals—that is to say, of his knowledge of systematic zoölogy.

Dr. Lones' book is too close-packed to be easy reading: it does not set forth to be a contribution to Aristotelian criticism, and here and there there are minor points of interpretation with which we are not inclined to agree. But be all this as it may, the book is meant to be useful, and it seems to me to make good its claim to usefulness. It is plain that the writing of it has been a labour of love and the work of years.

D. W. T.

HORTICULTURE.

Present-day Gardening.—Chrysanthemums.—By THOMAS STEVENSON, with Chapters by C. HARMAN PAYNE and CHARLES E. SHEA. 112 pages. *The Rock Garden.*—By REGINALD FARRER. 118 pages. *Tulips.*—By THE REV. J. JACOB. 116 pages. Each with 8 coloured plates. 8½-in. × 6¼-in.

(T. C. & E. C. Jack. Price 1/6 net. each.)

The three books whose titles are given above belong to a series which is being edited by Mr. R. Hooper Pearson, the Managing Editor of *The Gardeners' Chronicle*. The special feature of these useful volumes is that they are all written by experts, and that they are each illustrated with eight coloured plates reproduced from photographs by Mr. T. Ernest Waltham. Very many of these are strikingly beautiful, and they are the best pictures of their kind that have been produced for the purpose, while, when it is noticed that the price of the books is only 1s. 6d. each, it will be obvious that all lovers of flowers are to be congratulated on having many of the best varieties put before them as they appear in flower in addition to just the kind of information they require. The pictures of chrysanthemums may be specially mentioned, though the views in "The Rock Garden" are not quite so pleasing as the individual plants, probably owing to their backgrounds, though they give a good idea of the appearance of forms illustrated. Fifteen of the books have appeared and a number of others are in preparation.

W. M. W.

MYCOLOGY.

Fungoid Diseases of Agricultural Plants.—By JAKOB ERIKSSON, Fil.Dr. 208 pages. 117 illustrations. 8¼-in. × 5½-in.

(Baillière, Tindall & Cox. Price 7/6 net.)

The name of Professor Eriksson is a sufficient guarantee for the excellence of this text-book on the diseases of plants caused by fungi. On turning to the account of the rust-fungi (Uredineae), on which Professor Eriksson has published so extensively, one naturally finds a statement of the author's "mycoplasm" theory. These fungi have a somewhat complex life history, in the course of which several different kinds of reproductive cells are produced in succession, and until about ten years ago it was generally supposed that the infection of plants in spring or early summer was invariably due to the germination of spores which had passed the winter in a resting state. According to Eriksson, however, this explanation is insufficient to account for the spread of certain rust-fungi, and he claims to have discovered that the fungus can and does exist in the cells of the "host" plant as "a formless plasma body, a sort of *plasmodium*, symbiotically fused with the protoplasm of the cells, and forming together with these a *mycoplasm*" (to quote from the present work). "The mycoplasm-carrying cell presents otherwise a normal appearance, with nucleus, chlorophyl bodies, and so forth. There cannot be recorded any parasitical fungoid life that would waste away the host plant. We may surmise that the fungus in this way can exist in most of the chlorophyll-carrying cells, up to the ears and bloom, in all sorts of seed that are specially suitable for the fungus, or, as it is expressed, are in a higher degree susceptible. The period during which the fungus exists in this latent state varies in different cases. From four to five weeks it might last for as many months and even for some years. This is the *dormant* stage of the mycoplasm. Sooner or later, at a certain period of the life of the host plant, at a certain season, and with favourable environment of circumstances (soil, moisture, warmth, light, and so forth) for the development of the fungus, and varying with different sorts of rust, there will commence a new stage in the existence of the mycoplasm—the stage of *maturing*, when the fungus forces its way out from the symbiotic complex, penetrates the walls of the cell, and develops an intercellular mycelium. This maturing seems to be of short duration: it lasts only for a day or two, or possibly only some hours. As soon as the intercellular mycelium begins to form, it takes generally one week before open rust sores with spore-stuff begin to appear on the surface of the plant." It is only necessary to add that this remarkable explanation has received very little support from other investigators, to say nothing of its inherent improbability on general grounds. One cannot blame an author of a text-book for giving prominence to his own theories, but in this case some of the evidence *against* the mycoplasm theory might have been added, if only in a foot-note, for the guidance of students.

It is a pity this English version of Eriksson's book was not read through by a competent botanist in this country before publication. Had this been done, the English rendering would doubtless have been more elegant if less clingingly exact in its fidelity to the original, and we should not have met such

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queer terms as "isofaguous," "heterofaguous," and "parasitismus." There are numerous good illustrations, and a useful table of the fungoid diseases, arranged according to the host plants, is given in an appendix. The book is well got up, but seems rather expensive for its size.

F. C.

OCEANOGRAPHY.

Science of the Sea.—Prepared by The Challenger Society. Edited by G. HERBERT FOWLER, B.A., Ph.D., F.L.S. 452 pages. 217 figures and 8 charts. 8-in.×5½-in.

(John Murray. Price 6/- net.)

To those about to start on a long voyage who often ask how they can do some work for science, to yachtsmen, to naval officers who are apt to find time heavy on their hands in port or in a foreign station, this book has been addressed by the Challenger Society; for if they take up some of the subjects which are so admirably outlined in its pages they will enjoy an ever fresh interest in the sea, its workings and its inhabitants. It would not be easy to find any important matters which have been left out. The names of those who have contributed the various chapters are a guarantee that the information is sound and reliable. The air, water, shore, floating and fixed plants, floating animals and those of the sea floor are naturally considered; but we may turn from the hints as to dress and medicines, given by Professor Stanley Gardiner, to the interesting dissertation on the sea serpent by Professor D'Arcy Thompson. Yacht equipment, methods of dredging and trawling, and the preservation of marine organisms are all considered. The Editor gives some excellent advice as to notes and labels, and the material of which note-books should be made. The names of marine stations throughout the world should prove most useful for reference, as should also the chapter on literature; while the classified list of firms who will supply equipments, nets, apparatus and chemicals, though it might be amplified very considerably in some directions, has the advantage of containing only the names of those who are recommended from personal knowledge by the authors.

W. M. W.

PSYCHOLOGY.

An Introduction to Psychology.—By WILHELM WUNDT. Translated from the Second German Edition by RUDOLF PINTZER. 198 pages. 7½-in.×5-in.

(George Allen & Co. Price 3/6.)

Students of the science of psychology will welcome this brief expression of the long and patient researches of the veteran Leipsic Professor. It starts on the basis of experiment, and it goes no further beyond this basis than is legitimate in any scientific enquiry. To give a bare summary of its contents would be to do the author and our readers little service. We should advise all who are interested in the modern development of the subject, and in the manner in which the essentials take form in the mind of a great master, to read it and then to read it again. They must not expect to find this an easy matter. Notwithstanding lucidity of treatment, which is admirable and seldom fails in its aim, the concepts themselves are such as to demand close and prolonged attention. And Professor Wundt is not the man to slur over or sneak round difficulties, which are inherent in a subject so complex as that which deals with the constitution of the human mind. The principle on which he would lay the chief stress is that of "creative resultants." "It attempts to state the fact that in all psychical combinations the product is not a mere sum of the separate elements that compose such combinations, but that it represents a new creation." In logical phraseology there is always somewhat more in the conclusion than is contained in the premises. We believe that he is right in his emphasis on this principle. But if he regards it, as may be inferred from his mode of statement, as characteristic only of *psychical* combinations, we believe that he is mistaken. We regard this as true of *all* combinations which come under the comprehensive heading, "Evolution." His insistence on the importance of the principle is, however, in any case wise; and it is part of a work which is characterised by its wisdom.

C. LL. M.

The Composition of Matter and the Evolution of Mind.—By DUNCAN TAYLOR. 176 pages. 7½-in. × 5-in.

(The Walter Scott Publishing Co. Price 3/6).

To deal fully with this book in the columns of "KNOWLEDGE," would be a difficult task. We feel relieved from the duty of attempting it because this is not a journal of metaphysics. We use the term metaphysics in no disparaging sense; we employ it in contradistinction to science. By science we understand an enquiry into the phenomena of nature, taking the word nature in its widest sense, and into the concepts which are of value for the interpretation of these phenomena. By metaphysics we understand an enquiry into the ultra-phenomenal source (often called the cause) of nature and our knowledge thereof. That enquiry is beyond the limits of science which is content to accept the constitution of nature as something given, and to formulate the results of its enquiry in terms of correlation. It leaves all questions with regard to the source of origin of this constitution to metaphysics. Mr. Taylor urges that "The Omniscient Spirit of the omnipotent, inexhaustible Central Power holds and attracts all being by the means of the seminal interfusion of spiritual initiative, the positive element, in its atmosphere ether." He is very earnest in the expression of his views and uses freely the terminology of science. But it is quite impossible to discuss them here. It must suffice to have given a slight and necessarily inadequate indication of their scope.

C. LL. M.

TOPOGRAPHY.

British Association, Dundee Meeting, 1912.—By A. W. PATON, F.I.P.S., and A. H. MILLAR, LL.D., F.S.A. 683 pages. Illustrated. 7½-in.×5-in.

(David Winter & Son.)

It is customary for a handbook to be issued at each meeting of the British Association dealing with the place in which its annual gathering is held. The one produced by the Publications Committee at Dundee will be hard to beat, and not only has it proved of particular interest to the visitors, but it must be of permanent value to the residents and to the city. It deals with Dundee as it was, as it is, and as it may be; with its social problems; with its hospitals, and philanthropic institutions; with its public services, parks, slaughter-houses, water supply, museums and art galleries. The city is considered as an educational centre. There are no less than eighteen chapters on the subject of its present-day industries; nor are its ancient trades forgotten. Biographies of a number of its worthies are given. The scientific part occupies itself with geology and with the local flora, in connection with which coloured botanical surveys and geological maps are inserted in pockets in the covers of the book. There are special chapters on fossil fishes, mosses, birds, and the evolution of the race in Forfar, and perhaps only in the omission of local lists of other biological divisions will the handbook compare unfavourably in the minds of some with its predecessors. The seven hundred pages are rounded off with a consideration of art, the drama and music in Dundee. The Publications Committee is to be sincerely congratulated upon the result of its work, and in conclusion we quote the opening words of the "Welcome" with which the book begins: "We worship at the shrine where knowledge lifts a venerable head."

W. M. W.

ZOOLOGY.

The Individual in the Animal Kingdom.—By J. S. HUXLEY. 167 pages. 14 illustrations. 6½-in.×5-in.

(Cambridge University Press. Price 1/- net.)

Whether we agree or not with the author's conclusions set forth in this little book, its perusal leaves three distinct

impressions. First, that he is no mere armchair philosopher who has "dabbled" in biology, but a practical zoölogist with firsthand knowledge of what he writes about. Secondly, that he is a man of marked literary taste and ability, and thirdly, that he has thought for himself on a philosophical subject that has keenly interested biologists since the days of the "Naturphilosophen."

Mr. Huxley in his preface disarms criticism, for he points out that his facts are true whether or no we agree with him as to the particular meaning which he attaches to the philosophical use of the word "individual," and it is to a most interesting series of facts that he draws attention. The book is so written that the educated layman will have little difficulty in following the train of argument if he takes it seriously, while the zoölogist will doubtless learn new facts, the results of research recently published, that have not yet found their way into the textbooks. Dogiel's discovery of a new group of simple parasites, the Catenata, Woodruff's work on *Paramoecium*, and Newman and Paterson's remarkable account of Armadillo quadruplets, will assuredly be new to many who, like the present writer, strive in vain to keep themselves *au courant* with discoveries in zoölogy, amidst a rush of professional work.

The first chapter will probably be found least easy to follow; but it must be grappled with if the author's point of view is to be understood. The remaining ones are all more or less easy reading. The illustrations call for no comment; but we could wish that less use had been made of footnotes. It only remains to be said that the book should have a wide sale, and the author must be congratulated on the interesting and stimulating manner in which he has put forth his conclusions on some important points.

SATURN.

By FRANK C. DENNETT.

OF all celestial objects Saturn stands alone as an example of exquisite beauty. As an object for continuous study many other bodies doubtless are of greater interest, either from lower instrumental powers being of greater service, or from constant physical happenings bringing continual change. But as an object of beauty Saturn is unrivalled. The ball, some seventy-five thousand miles in diameter, is marked, even more regularly than Jupiter, with belts parallel with its equator. Some of these are easily observable with a telescope so small as two and a quarter inches in aperture. But to see the whole, with the exquisite colours they display, will tax the powers of the best instruments under the most favourable conditions. The form of the globe is best seen when the rings are presented edgeways. Apparently then one of the poles is flattened rather more than the other.

The ring system is the cause of the exceeding beauty. It may well have puzzled the first observers with their inferior instruments. Nowadays, seeing that we have some knowledge of the nature of the object, even a two-inch achromatic will give a pretty view, when the rings are widely open as they are now. Every increase of aperture, however, adds to the beauty. A two and a half inch to three inch reveals the fact that the ring is divided into at least two parts, an outer ring and an inner. This was first discovered in 1675 by Cassini, hence the division is often known as Cassini's. It was at one time called Ball's through a mistaken interpretation of the writings of one of the brothers Ball. It will be seen that the inner ring is brightest and fades inwards, also that the outer ring is not evenly bright. A little increase of aperture reveals the presence of the inner "crape veil," the semi-transparent ring discovered simultaneously in England and America by Dawes and Bond respectively, in 1850. That it was in existence previously there can be no doubt, because Cassini shows its form where it crosses the planet so far back as 1715. Yet the Herschels and Schroeter with their giant reflectors, and Struve with the 9·6 inch Dorpat achromatic repeatedly studied the planet and missed it. In 1880 it could not have well been overlooked even with a four and a half-inch reflector.

The ring system presents many problems. In the first place, the ball is not exactly in the middle of the rings, but just a little to the west of the centre. This has been noted even with quite small instruments. The Cassini division, too, is not always equally dark. The outer ring has a division in it known as Encke's, from his careful measures of its position. The peculiarity of this division is that on equally propitious nights, and with the same instrument, the division is variable. Sometimes it may be seen hard and sharp in one ansa, whilst no trace of it can be found in the other. Sometimes the best instruments fail to reveal it, whilst at others it is like a mere pencil marking. Further, it is not a fixture, sometimes appearing nearer the inner edge, at others nearer the outer. Occasionally it has appeared to be accompanied by other still finer divisions. The middle ring usually seems simply to fade inwards, but sometimes appears to be sensibly stepped, and it has been observed apparently divided by at least three narrow divisions. The inner dusky ring looks at times as if in contact with its neighbour, at others, separated from it by a division, whilst occasionally the "crape veil" has itself seemed to be split by a division.

Another mystery of the rings is that the outline of the planet's shadow upon the rings has appeared not smooth, but notched. The best explanation of this is to be found by supposing that the rings are either not all of the same thickness, or else—or perhaps also—that they are not all in the same plane. This last suggestion is seemingly borne out by the fact that at the last time when the rings were presented edgeways they never quite disappeared even with a three-inch achromatic, whilst with larger instruments they appeared as bright knobs or beads.

Were the ring-system solid it would not be stable as the outer portions would be travelling at a much greater rate than the inner. This would inevitably lead to disruption: the inner portions travelling too slowly would be drawn downward upon the planet, whilst outer parts travelling too rapidly would rush off—away from the planet's control. Keeler's spectroscope proved that the rings were not solid; that the inner portions were travelling, in accordance with necessity, much faster than the outer portions. The consequence of this is that there is a constant change of the particles with respect to each other. This explains the irregular density observed at the extremities of the curves from time to time as seen with the largest instruments, and the variations in the divisions. At present, November, 1912, Saturn is in good position for observation, high up in the heavens between the Pleiades and Aldebaran. Moreover, the rings are at such an angle that the northern pole is hidden behind the rings, whilst the southern one is apparently bedded on them. Although Saturn is not so brilliant as Jupiter, it is a remarkable fact that the same telescope can be used with higher powers on the former than upon the latter with good result. The five older known moons may be observed with any telescope of about four inches in diameter; but they are not so interesting as those of Jupiter, as their phenomena are not so easily observed. Dual discovery was again shown when Lassell, in England, and Bond, in America, simultaneously found the tiny Hyperion in 1848. This satellite, like the oldest known, Rhea, Dione, Titan, and Iapetus, displays variations in its brightness in different parts of its orbit, variations which seem to indicate that, like our Moon and some of Jupiter's, they always present the same face to their primary.

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THE FACE OF THE SKY FOR DECEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Dec. 1	16 29·0	S.21·8	10 48·1	N.10·5	17 34·3	S. 24·2	19 11·3	S. 24·5	3 53·0	N.18·0	20 12·1	S.20·6	7 50·4	N.20·5
,, 6	16 50·7	22·5	14 56·7	S. 20·0	17 15·9	22·3	19 37·5	23·7	3 51·3	17·9	20 12·9	20·5	7 50·0	20·5
,, 11	17 12·6	23·0	19 34·2	S. 26·7	16 48·0	20·2	20 3·4	22·6	3 49·8	17·9	20 13·9	20·5	7 49·6	20·5
,, 16	17 34·7	23·3	23 27·7	S. 5·3	16 30·4	18·9	20 28·6	21·2	3 48·3	17·8	20 14·9	20·4	7 49·1	20·6
,, 21	17 56·9	23·5	3 21·8	N.22·2	16 30·6	19·1	20 53·2	19·6	3 46·9	17·7	20 16·0	20·4	7 48·6	20·6
,, 26	18 19·1	23·4	8 39·8	N.23·0	16 44·1	20·1	21 17·1	17·8	3 45·6	17·7	20 17·0	20·3	7 48·1	20·6
,, 31	18 41·3	S.23·1	13 4·3	S. 7·8	17 5·8	S. 21·3	21 40·4	S. 15·8	3 44·5	N.17·6	20 18·2	S.20·2	7 47·5	N.20·6

TABLE 46.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Saturn. P	Saturn. B
Greenwich Noon.	°	°	°	°	°	°
Dec. 1	+16·1	+0·7	54·6	+20·9	−2·7	−24·8
,, 6	14·1	+0·1	348·7	+15·4	2·6	24·9
,, 11	11·9	−0·6	282·8	−8·8	2·6	24·9
,, 16	9·7	1·2	216·9	−21·7	2·5	24·9
,, 21	7·3	1·8	151·1	−13·6	2·5	25·0
,, 26	4·9	2·4	85·2	+14·0	2·4	25·0
,, 31	+2·5	−3·0	19·4	+21·0	−2·4	−25·0

TABLE 47.

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN moves South till December 22nd, reaching the Solstice at $5^h m$ on that day. Sunrise during December changes from 7–44 to 8–8; sunset from 3–53 to 3–58. Its semi-diameter increases from 16′ 15″ to 16′ 18″. Nearest Earth 1913, January 1st.

MERCURY is an evening star till December 8th, then a morning star. At greatest elongation 22°·4 W. December 28th. Illumination, December 1st one-fifth, December 8th zero, December 31st seven-tenths.

VENUS is an evening Star, approaching its greatest elongation. Illumination three-quarters, semi-diameter $7\frac{1}{2}''$.

THE MOON.—Last Quarter $1^d\ 11^h\ 5^m m$; New $8^d\ 5^h\ 7^m e$; First Quarter $16^d\ 8^h\ 6^m e$; Full $24^d\ 4^h\ 30^m m$; Last Quarter $30^d\ 8^h\ 12^m e$. Apogee $14^d\ 7^h m$, semi-diameter 14′ 47″; Perigee $26^d\ 3^h m$, semi-diameter 16′ 32″. Maximum Librations, December 6^d 5° W., 10^d 7° N., 20^d 7° E., 24^d 6° S. January 1^d 6° W. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

Date.	Star's Name.	Magnitudes.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1912.			h. m.	°	h. m.	°
Dec. 2 ...	σ Leonis	4·2	—	—	0 44 *m*	314
,, 3 ...	BD − 0°2554	7·6	—	—	3 18 *m*	297
,, 12 ...	BAC 7128	6·3	4 10 *e*	49	5 25 *e*	258
,, 17 ...	44 Piscium	6·0	6 1 *e*	340	6 26 *e*	302
,, 20 ...	19 Arietis	5·8	3 12 *m*	59	—	—
,, 20 ...	36 Arietis	6·5	3 37 *e*	116	4 12 *e*	185
,, 20 ...	40 Arietis	6·0	6 0 *e*	135	6 17 *e*	163
,, 21 ...	BD + 22°545	7·0	6 45 *e*	71	—	—
,, 21 ...	BAC 1170	5·5	8 7	71	9 20 *e*	242
,, 22 ...	36 Tauri	5·6	4 21 *m*	143	4 46 *m*	202
,, 23 ..	BAC 1848	5·6	6 50 *e*	16	7 17 *e*	323
,, 23 ..	136 Tauri	4·6	7 31 *e*	124	8 17 *e*	217
,, 25 ...	47 Geminorum...	5·6	0 36 *m*	138	1 33 *m*	243
,, 25 ...	BAC 2383	6·5	3 11 *m*	112	4 15 *m*	279
,, 26 ...	BD + 24°1903	7·0	—	—	2 11 *m*	353
,, 26 ...	λ Cancri	5·9	2 19 *m*	59	3 0 *m*	346
,, 26 ...	BD + 21°1969	7·7	—	—	7 55 *e*	322
,, 28 ...	37 Leonis	5·5	0 46 *m*	87	1 45 *m*	333
,, 30 ...	BAC 4043	6.5	0 11 *m*	128	1 11 *m*	294

TABLE 48. Occultations of stars by the Moon visible at Greenwich.

From New to Full disappearances occur at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, but practically invisible.

JUPITER is invisible, being in conjunction with the Sun on December 18th.

SATURN was in opposition November 23rd. Polar semi-diameter 9½″. The major axis of the ring is 47½″, the minor axis 19½″. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

East elongations of Tethys (every fourth given). December $1^d\ 11^h{\cdot}5\ e$, $9^d\ 0^h{\cdot}7\ e$, $17^d\ 1^h{\cdot}8\ m$, $24^d\ 3^h{\cdot}0\ e$. Dione (every third given). December $1^d\ 3^h{\cdot}7\ e$, $9^d\ 8^h{\cdot}6\ e$, $18^d\ 1^h{\cdot}6\ m$, $26^d\ 6^h{\cdot}6\ m$.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
Nov. 25 to Dec. 12	189	+ 73	Rather swift.
Dec. 4 ...	162	+ 58	Swift, streaks.
,, 6 ...	80	+ 23	Slow, bright.
,, 8 ...	145	+ 7	Swift, streaks.
,, 8 ...	208	+ 71	Rather swift.
,, 10–12	108	+ 33	Swift, short.
,, 12 ...	119	+ 29	Rather swift.
,, 22 ..	194	+ 67	Swift, streaks.
,, 21—22	117	+ 47	Swift.
,, 31 ...	92	+ 57	Slow, bright.

The shower Dec. 10—12 is a conspicuous one.

Rhea (every second given). December $4^d\ 9^h{\cdot}9\ e$, $13^d\ 10^h{\cdot}6\ e$, $22^d\ 11^h{\cdot}2\ e$, $31^d\ 12^h{\cdot}0\ e$.

For Titan and Iapetus, E. W. mean East and West elongations, I., S. Inferior and Superior Conjunction, Inferior being to the North, Superior to the South. Titan, $2^d\ 0^h{\cdot}7\ m$ I., $5^d\ 8^h{\cdot}6\ e$ W., $9^d\ 6^h{\cdot}9\ e$ S., $13^d\ 9^h{\cdot}6\ e$ E., $17^d\ 10^h{\cdot}1\ e$ I., $21^d\ 6^h{\cdot}2\ e$ W., $25^d\ 4^h{\cdot}6\ e$ S., $29^d\ 7^h{\cdot}5\ e$ E. Iapetus $2^d\ 11^h{\cdot}8\ e$ I., $21^d\ 11^h{\cdot}3\ e$ W.

URANUS is an evening Star, semi-diameter 2″. It is 7½° South of Alpha Capricorni, 5° South-West of Beta. It is 1½° North of Venus on the 14th.

NEPTUNE is a morning star, approaching opposition.

CLUSTERS AND NEBULAE.

Name.	R.A.	Dec.	Remarks.
♓ III. 25	3h 8m	N 47°·0	Faint cluster.
♓ I. 60	3 22	S 21 ·7	Nebula.
♓ I. 107	3 36	S 18 ·9	Nebula.
Pleiades	3 39	N 23 ·5	Well-known cluster. Photography shows many nebulae.
♓ IV. 53	3 59	N 60 ·6	Planetary nebula.
♓ VII. 61	4 7	N 51 ·0	Bright cluster.
♓ IV. 26	4 10	S 12 ·9	Planetary nebula.
B. 94	4 55	S 14 ·9	Remarkable red variable star.

DOUBLE STARS.—The limits of R.A. are 3^h to 5^h.

Star.	Right Ascension. h. m.	Declination.	Magnitudes.	Angle. N. to E.	Distance.	Colours, etc.
52 Arietis	3 1	N 25°·0	6, 6	95°	½	Bluish-white.
	A tenth magnitude star at 356°, 5″.					
7 Tauri	3 29	N 24 ·2	6½, 6½	180	¼	White, yellow.
	A tenth magnitude star at 60°, 22″.					
WB (2) III. 657-8... ...	3 34	N 34 ·0	7, 7	90	2½	White.
o Persei	3 39	N 32 ·0	4, 8	237	19	White, ash.
Piazzi III. 160	3 55	N 80 ·5	5, 6	60	1	Yellow, blue.
ζ Persei	3 48	N 31 ·7	3, 9	206	13	Yellow, blue.
32 Eridani	3 50	S 3 ·2	4, 6	349	6	Yellow, purple.
ε Persei	3 52	N 39 ·8	3, 8	8	9	Greenish, blue.
Σ 484	4 0	N 62 ·0	6, 6	303	18	Whitish-yellow.
	In cluster ♓ VII 47.					
o^2 Eridani	4 11	S 7 ·7	4, 9	40	2	Yellow, blue.
	Period about 170 years. A star distant 82″ also belongs to the system.					
1 Camelopardi	4 25	N 53 ·8	5, 6	306	10	Bluish-white.
2 Camelopardi	4 33	N 53 ·4	5, 7	288	1½	Yellowish, bluish.
	There is also a very close companion, distant one-fifth of a second.					
Lalande 8693	4 33	N 26 ·8	6½, 6½	202	3½	White.
7 Camelopardi	4 50	N 53 ·6	4½, 8	303	1½	Yellowish, white.
ω Aurigae	4 53	N 37 ·8	5, 8	354	6	Greenish, bluish.

TABLE 49.

CORRESPONDENCE.

WASTE IN COOKING.

To the Editors of "KNOWLEDGE."

SIRS,—In the very interesting article appearing in the current number of "KNOWLEDGE" under the title of "On Cooked Foods" the following sentence occurs:—

"With regard to meat it is stated that however cooked it loses from one-fifth to one-third of its weight."

It may interest your readers to know that meat may be cooked in electric ovens in such a manner that the loss is not more than from one-twentieth to one-eighth of its weight, or in other words from five to fourteen per cent.

To obtain these results it is, of course, necessary that the cook shall understand the proper use of an electric oven; but this is easily learnt.

The extraordinary difference in shrinkage between meat cooked in an electric oven and meat cooked in any other way, seems to be due partly to the fact that electric ovens being practically airtight very little evaporation takes place, and partly to the evenness of electrically generated heat. There are probably other reasons which though not apparent to a cook, would at once occur to a scientific mind.

If any of your readers could explain the matter from a scientific point of view it would be extremely interesting, and it seems to me that the whole subject is one which in the interests of economy cannot be too widely ventilated.

AMY CROSS,
First Class Diplomée National Training School of Cookery.

XUM

NOTICES.

INSTRUCTION IN PHOTOGRAPHY.—We have pleasure in announcing that Mr. Senior, our photographic editor, is giving a course of instruction in photography at the Central Young Men's Christian Association, Tottenham Court Road, on Friday evenings.

FIRST AID.—We have received a well-illustrated little booklet, dealing with Famous Airmen and their Equipments, from Messrs. Burroughs, Wellcome & Company, which also contains some useful notes on first aid.

FABRE'S WORKS.—Messrs. Hodder & Stoughton announce that they will publish this autumn the first volume of the collected works of J. H. Fabre, the eminent French naturalist, which will be issued under the title of "The Life of the Spider."

ZOÖLOGICAL LITERATURE.—We have received from Mr. Felix L. Dames, of Steglitz, Berlin, his one hundred and twenty-fifth catalogue of Zoölogical Works—two thousand five hundred odd in number. They are classified under various useful headings, and among them are many books and papers which are not often seen in second-hand lists.

SECOND-HAND APPARATUS.—From Mr. C. Baker comes a classified list of second-hand instruments, which is issued three times a year. As on previous occasions, we commend its seventy-four pages to those who need good microscopes, lenses, and other apparatus of first-class quality, at reasonable prices.

We have received as well Messrs. Clarke & Page's second-hand list, which should also be consulted.

THE TAIT MEMORIAL.—The committee appointed to suggest the form which the memorial to Professor Tait should take recommends the raising of a fund of from £20,000 to £25,000 for the purpose of endowing a second Professorship in Natural Philosophy in the University of Edinburgh. Pamphlets dealing with Professor Tait and his work, as well as the need for the Professorship, have been issued, together with the names of the general committee, who appeal for subscriptions to be sent to the honorary treasurer, Sir George M. Paul, 16, St. Andrew's Square, Edinburgh.

SELBORNE CENTRAL LECTURES.—The Selborne Society has arranged the following central lectures for the coming session:—

1912.

Nov. 11.—"Fairy Flies and their Hosts"
FRED ENOCK, F.L.S., F.E.S.

,, 25.—"The Elizabethan Playhouses of London"
WILLIAM MARTIN, M.A., LL.D., F.S.A.

Dec. 9.—"English Cathedrals" (Second Series)
CHARLES E. KEYSER, M.A., F.S.A.

1913.

Jan. 9.—Special Children's Lecture on "Dew, Hoar Frost and Cloud" SPENCER FLETCHER, F.R.A.S.

,, 20.—"On Minor Planets"
A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Feb. 17.—"Fibres and Fibre Lore"
C. AINSWORTH MITCHELL, B.A., F.I.C.

Mar. 3.—"Byways of Biology"
JAMES SAUNDERS, A.L.S.

The lectures will be given in the Theatre of the Civil Service Commission, Burlington Gardens, New Bond Street, at 6.30 p.m., except Mr. Enock's, which will be at 6.45, and the Children's Lecture, which will take place on a Thursday, at a time to be announced. Members may personally introduce one friend. Tickets to Members, price 6d. each; to Non-Members, 1s.

"THE "THIRD HAND" THUMB MAGNIFIER.—Our readers may remember that we described and illustrated in our microscopical column an ingenious contrivance called the "Focostat," which consisted of a lens fastened on to one's dissecting needle or pen. The "Third Hand" magnifier is a larger lens, which by means of a clip, as its name implies, can be attached to the thumb, and it will prove extremely useful where the hand to which it is fastened need not be

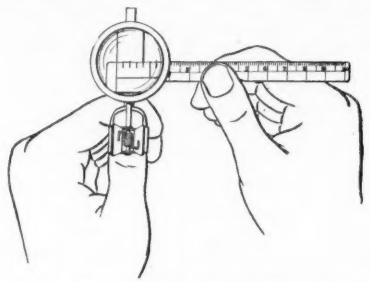

FIGURE 472. The "Third Hand" Thumb Magnifier.

moved. The magnifier is well adapted for reading fine scales (see Figure 472), and even for domestic purposes, such as the threading of needles. It has been brought out by "Third Hands" Patents, Limited, of City Road.

THE MUNICIPAL MUSEUM, HULL.—On Wednesday evening, the 16th October, a new gallery was opened at the Municipal Museum, Hull, which is to be entirely devoted to the illustration of local mammals. The specimens include several historical examples from the collection of the late Sir Henry Boynton, and other sources, and some of them are the last records of the kind for the district. The collection is arranged in specially-made cases, in which the animals are shown in their natural surroundings, in addition to which there are several large groups showing male, female and young of Otters, Badgers, Hedgehogs, Deer, Foxes, and so on. On the occasion mentioned the curator, Mr. T. Sheppard, gave an address on the Mammals of the East Riding of Yorkshire.

FORGED EGYPTIAN ANTIQUITIES.—Within recent years a great demand has arisen for relics of Ancient Egypt, and large sums of money are spent by the public each year in the purchase of scarabs, pottery, figures, and so on, which are said to have been taken from the tombs in that country. Many of these objects are frauds, and of quite recent manufacture, but as the itinerant sellers have a most plausible manner and a glib tongue, travellers are frequently taken in, and pay large sums of money for worthless specimens. It is with the object of giving some guidance to those interested in Egypt and its antiquities that Messrs. A. & C. Black are publishing a book, by Dr. T. G. Wakeling, entitled, "Forged Egyptian Antiquities," which will be illustrated with many examples of objects usually offered for sale.

HORNIMAN MUSEUM LECTURES. — We have received a list of the ten free public lectures which will be given in the Lecture Hall, Horniman Museum, Forest Hill, at 3.30 p.m., on Saturday afternoons. We print the titles of those which still remain to be given at the time of going to press:—

Nov. 2.—"The Botany of Bread"
MISS E. M. DELF, B.A.

,, 9.—"Money before Coins" MR. A. R. WRIGHT, F.R.A.I.

,, 16.—"Animal Parasites and their Life Histories"
DR. W. A. CUNNINGTON, M.A.

,, 23.—"A Folk-lore Tour in Brittany"
MR. EDWARD LOVETT.

,, 30.—"The Origin and History of Dogs"
MR. H. N. MILLIGAN, F.Z.S.

Dec. 7.—"Shoes and Sandals of the Past"
MR. A. R. WRIGHT, F.R.A.I.

,, 14.—"Women's Work in Central Africa"
DR. W. A. CUNNINGTON, M.A.